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ABSTRACT

This study investigated the feasibility of a low cost computer-aided instruction/computer-managed instruction (CAI/CMI) system. Air Force instructors and training supervisors were surveyed to determine the potential payoffs of various CAI and CMI functions. Results indicated that a wide range of capabilities had potential for resident technical training. Surveys of selected computers, terminals, communications, and support software identified candidates for the low cost system. (Author)

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AIR FORCE HUMAN RESOURCES LABORATORY

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LOW-COST COMPUTER-AIDED INSTRUCTION/ COMPUTER-MANAGED INSTRUCTION (CAI/CMI) SYSTEM:

FEASIBILITY STUDY

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Final Report

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This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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SUMMARY

PROBLEM

Prototype computer-based, multimedia, individualized training systems have demonstrated that the concept of computer-assisted instruction/computer-managed instruction (CAI/CMI) is valuable and is directly applicable to an operational Air Force training environment. Substantial savings in training times and more efficient utilization of resources have been demonstrated. However, the prototype systems incorporated research capabilities which were not essential to effective routine support of the majority of Air Force training. The purposes of this study were (a) to identify those CAI/CMI functions with the greatest potential payoff for Air Force training and (b) to develop a functional specification for a low-cost computer-based system.

APPROACH

The applicability of and requirements for CAI and CMI in various Air Force training environments were determined by surveying potential user personnel. Computer system architectures were surveyed to determine candidate systems to meet the functional requirements of the low-cost CAI/CMI system. Alternative terminal hardware devices and communication systems were surveyed, in order to recommend an economical set of input/output devices and communications interface to meet the functional requirements of the system. Various computer programming languages were analyzed to identify a language which would be cost effective for CAI/CMI programming. The CAI/CMI applications software area was surveyed, to determine the extent to which existing software might meet Air Force training needs.

The initial assumptions used to set the scope of the study were as follows: the computer, terminals, communications, programming language, and applications software must be capable of

1. Supporting 500 students per shift, in 1500 hours of instruction across five courses, with 150 instructional hours of CAI and with five CMI transactions per student per shift.

2. Providing a proven student progress management approach.

3. Supporting the production and evaluation of instructional materials for on-line and off-line use.

4. Providing a set of standard reports for various levels of Air Force instructional personnel, with flexible capability to retrieve and analyze training performance data for special purpose reports.

RESULTS

Air Force instructors and supervisory personnel identified a broad range of functional capabilities in the CAI and CMI areas with potential payoff for training. A total of 167 functions from seven major CAI/CMI functional areas are recommended for inclusion in the Air Force low-cost system.

A survey of central processing units identified a minicomputer configuration as the principal candidate for meeting the functional requirements of a dedicated local system. The concept of stand-alone devices was considered briefly. It became obvious that the myriad of combinations could not be dealt with within the scope and time frame of the study.

A survey of terminals and communications resulted in recommendations for a candidate low-cost student/administrative terminal, a low resolution graphics terminal with color CAI capability, a high resolution graphics terminal for CAI, and a management terminal reader/printer configuration.

The survey of applications software indicated that all of the recommended functions have been implemented on one or more existing computer-based instruction systems, demonstrating the technical feasibility of implementing the recommended functions. At the present time, various computer-based systems present more or less of the recommended functions. Some of these existing systems, however, are implemented on large centralized mainframes capable of supporting satellite operations, and incorporate sophisticated research and development capabilities that are not essential to routine support of the majority of Air Force training.

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1.0 INTRODUCTION

Prototype computer-based individualized training systems have been developed and implemented at a number of Department of Defense (DOD) and civilian installations. One such training system is the Advanced Instructional System (AIS) at Lowry AFB. The results of a variety of research and development (R&D) projects indicate that

1. Application of computer-based instruction (CBI) resulted in substantial savings in training time and more efficient utilization of resources.
2. An operational training system does not need sophisticated research capabilities which, although incorporated into prototype systems and required for research, are not essential to effective support of the majority of resident technical training operational requirements.
3. Full and economical exploitation of the demonstrated operational capabilities of the prototype systems in routine support of resident training requires additional application and system refinement.

Innovations in computer technology have drastically reduced the prices of computer components and terminals. Consequently, the goals of computer-based training should be reexamined in the context of 1979 state-of-the-art computer technology.

The present study establishes the requirements for a purely operational system and integrates those requirements into a system design based on the best of current computer technology. The principal objective was to design a cost-effective system configuration which would efficiently support the CBI functions identified as having potential payoff from an operational viewpoint, without including "nice to have" or "rich" capabilities in support of R&D functions. The products of this study are as follows:

1. An overall system specification, delineating a set of functional requirements for a low cost computer-assisted instruction/computer-managed instruction (CAI/CMI) system (Appendix H).
2. This Technical Report, presenting the assumptions, data collection methods, analyses, and results related to CAI and CMI system capabilities, selected system architectures, communication systems, terminal hardware, and programming languages and software. This report includes the configuration of an example low-cost CAI/CMI system with communications equipment, terminal hardware, applications programs software, and a language which will satisfy the operational requirements within established constraints and assumptions.

2.0 STUDY PLAN

The research plan called for accomplishment of the following major tasks:

1. Determine Functional Requirements of Users - survey Air Force users, analyze survey data, and determine functional requirements for a low-cost CAI/CMI system for operational use in Air Force resident technical training programs.

2. Survey Hardware, Software, and Systems - survey available hardware, software, and languages, and identify candidates for central processor units (CPUs), communications, terminals, software, and languages.

3. Document and Design - write a functional specification and configure an example of a state-of-the-art hardware/communications/terminals/software system to meet the functional requirements.

Figure 1 illustrates the task flow for this research plan. The following paragraphs describe procedures for accomplishing the tasks.

In order to provide a framework around which the design work of this study could proceed, some assumptions were made regarding the intended uses and environment for the low-cost CAI/CMI System. These assumptions are as follows:

1. System design will be oriented toward resident technical training.

2. System design will be oriented toward a dedicated local system, rather than a large centralized mainframe-oriented system or stand-alone minisystems. A modular approach to expansion will be incorporated, to facilitate tradeoffs such as fewer on-line students in exchange for heavier CAI usage. The effects of increased loads on memory and mass storage requirements will be considered.

3. System design will be targeted toward providing operational CAI/CMI support for approximately 500 students per shift. It is also assumed that: the 500 students are distributed across five different courses; the five courses account for 1,500 hours of instruction; each student averages five CMI transactions per shift; not more than 10% of the students are using CAI at any one time; not more than nine administrators (instructors or supervisory personnel) are on-line simultaneously; and batch processing is accomplished off-shift (i.e., during periods of low or no student CAI/CMI load).

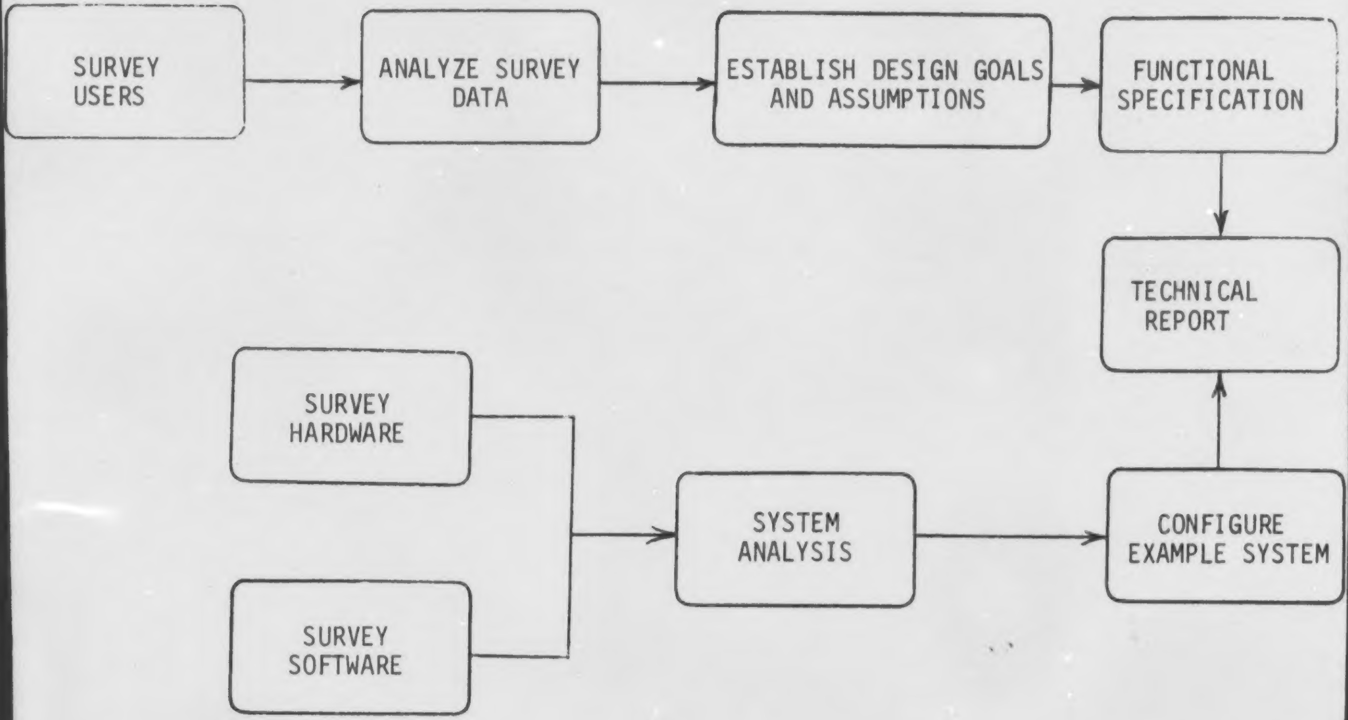
SURVEY USERS
ANALYZE SURVEY DATA
ESTABLISH DESIGN GOALS AND ASSUMPTIONS
FUNCTIONAL SPECIFICATION
TECHNICAL REPORT
SURVEY HARDWARE
SURVEY SOFTWARE
SYSTEM ANALYSIS
CONFIGURE EXAMPLE SYSTEM

FIGURE 1. TASKS FOR LOW-COST SYSTEM STUDY

3.0 FUNCTIONAL REQUIREMENTS OF USERS

The initial step toward designing a low-cost CAI/CMI system was to determine those computer-provided functions which would be of value in Air Force training. To this end, the following tasks were accomplished:

1. Preparation of a listing of CAI and CMI functions which could be provided by a computer-based training system.
2. Preparation of a rating scale with which Air Force users could estimate payoff potentials for various CAI/CMI functions.
3. Identification of a suitable sample of potential Air Force users of a low-cost CAI/CMI system.
4. Collection of data from the sample of potential users.
5. Analysis of the data.
6. Determination of the CAI and CMI functions which should be provided by the low-cost system.

3.1 LISTING OF CAI/CMI FUNCTIONS

A comprehensive listing of 184 potential CAI and CMI functions was developed, describing those functions which could be incorporated into a CBI system. This listing was intended to include any technically feasible functions which could be provided for Air Force training by a computer based system, and which were not considered to be R&D functions. The outcome of this effort was a listing of functions in seven major areas: Student Testing and Evaluation, Student Assignment, Student Progress Management, Support for Guidance and Counseling, CAI, Production and Maintenance of CMI Data Base and CAI Materials, and Information and Reports (see Appendix A).

The Appendix A listing of the 184 functions includes the numbering scheme that is used throughout this report in referring to individual CAI/CMI functions--Roman numerals designate the seven major areas, followed by letters and Arabic numbers that designate subcategories and individual functions.

3.2 PREPARE RATING SCALE AND SURVEY FORMS

The 184 CAI/CMI functions were incorporated into survey forms, with a rating scale intended for use by Air Force training and management personnel in estimating the relative values that the functions would have for operational training. The rating scale was oriented toward the concept of "payoff potential." The introduction to the survey form and the explanation of the rating scale are shown in

Appendix B. The explanation points out that payoff potential for Air Force training can come from any of the following:

- Reduced training time - students get through faster.
- Reduced administrative load on instructors.
- More efficient use of training resources.
- Improved quality control over students and/or courseware.
- Improved management/administration of training.
- Improved courseware development and evaluation processes, resulting in better instructional materials and reduced development times.

The instructions for using the rating scale (Appendix B) asked participants to consider how much each of the functions would be worth to Air Force training within the context of the participant's duty assignment, and to assign ratings using the following scale:

1 = Very high payoff potential.

2 = High payoff potential.

3 = Moderate payoff potential.

4 = Low payoff potential.

5 = No payoff potential.

X = No opinion - this function's effects would be outside my area, and I cannot estimate its payoff potential.

Because of the large number of CAI/CMI functions included in the listing, two survey forms were prepared. One form included the functions that were of potential value in the conduct of resident technical training at the instructor level. The second form included the functions that were of potential value for Air Force managers and supervisors--e.g., course supervisors, branch chiefs, and training advisors.

The instructor survey form asked for ratings on the following items (see Appendix A):

Category I (Student Testing and Evaluation), all items except item IB.

Category II (Student Assignment), all items except item IID.

Category III (Student Progress Management), all items.

Category IV (Support for Guidance and Counseling), all items.

Category V (Computer Aided Instruction), all items.

Category VI (Production and Maintenance of CMI Data Base and CAI Materials) all items except item VIC.

Category VII (Information Retrieval and Reports), all items listed under VIIA, Reports for Instructors.

The supervisor survey form asked for ratings on the following items (see Appendix A):

Category I (Student Testing and Evaluation), items IA, IB, IC, and ID.

Category II (Student Assignment), items IIA, IIB, IIC, IID, IIE, and IIF.

Category III (Student Progress Management), items IIIA, IIIB, IIIB3-5, and IIIC.

Category IV (Support for Guidance and Counseling), items IVA and IVB.

Category V (Computer Assisted Instruction), items VA, VB1-7, and VC.

Category VI (Production and Maintenance of CMI Data Base and CAI Materials), Items VIA1-2, VIB, VIC, VID1-6, VIE, VIE1-6 and VIF.

Category VII (Information Retrieval and Reports), all items.

Quantities of the survey forms were reproduced for use in the data collection effort. Participants in the survey marked their responses directly on their copies of the forms, and identified themselves by duty position. Names or other specific identification were not required.

3.3 SAMPLING OF POTENTIAL USERS

Although the design of the low-cost system was to be oriented principally toward the needs of resident technical training, the needs of other Air Force training programs were also to be identified. This would permit documenting the extent to which the low-cost system would meet the needs of, for example, on-the-job training (OJT), navigator training, and field training detachments (FTDs). Therefore, samplings of potential users from resident technical training and from a number of other Air Force training programs were identified for inclusion in the survey of user requirements.

3.3.1 Resident Technical Training Sample

The sample of resident technical training personnel was drawn from Air Training Command (ATC) Headquarters at Randolph AFB and from four Air Force Technical Training Centers (TTCs)--Sheppard, Keesler, Chanute, and Lowry.

During the AIS development contract, courses at the TTCs were analyzed to identify those which were prime candidates for inclusion in any expansion of the Air Force's CBI effort. Based on that earlier analysis, the following courses were included in this survey of user requirements:

Sheppard TTC

Air Cargo Specialist (3BRB60531)
Disbursement Accounting Specialist (3ABR67232)
Faculty Development (3AIR75100-4)

Keesler TTC

Personnel Specialist (3ABR73230)
Ground Radio Equipment Mechanic (3ABR30434)
Telecommunication System Control Specialist (3ABR30730)
Faculty Development (3AIR75100-4)

Chanute TTC

Aerospace Ground Equipment Repairman (3ABR42335)
Life Support Specialist (3ABR92230)
Airframe Repair Specialist (3ABR42735)

Lowry TTC

Munitions Maintenance Specialist (3ABR46130)
Inventory Management Supervisor (3ABR64570-1)
Faculty Development (3AIR75100-4).

Personnel from several other ATC resident technical training programs were included in the user survey because of their involvement with, and knowledge of, Air Force computer-based training:

Sheppard TTC (users of PLATO)

Health Care Sciences

Chanute TTC (users of PLATO)

Vehicle Repairman (3ABR47231, 3ABR47232)
Aircraft Pneudraulics (3ABR42334)
Plans and Requirements Division
PLATO Development Group

Lowry TTC (users of AIS)

Inventory Management Specialist (3ABR64530)
Materiel Facilities Specialist (3ABR64531)
Precision Measuring Equipment Specialist (3ABR32430)
Weapons Mechanic (3ABR46230).

The Air Force memoranda requesting the TTCs' participation in the survey of user needs requested "...cooperation in the Feasibility Study Survey of the following individuals/agencies involved with conduct of the above courses:

1. The Deputy Commander for Training
2. The Training Advisor
3. The Technical Training Group Commander(s)
4. The Chief, Plans/Requirements Division
5. The Chief, Branch Curriculum Development Unit
   -Resident Course Representatives
   -Nonresident Course Representatives
   -Instructor and Course Evaluation (I&M) Representatives
6. Course Supervisors of the above Courses
7. Ten Instructors from each of the above Courses."

The participation of personnel from Technical Training (TT) and Plans (XP), HQ ATC Randolph AFB, was also requested. These staff agencies are responsible for planning, programming, administering, and managing ATC technical training at the ATC Headquarters level.

3.3.2 Other Air Force Training Sample

The following instructors and supervisors from training programs other than resident technical training were identified for inclusion in the survey of user requirements:

1. FTD/OJT instructors and supervisors from Sheppard, Mather, and Davis Monthan AFBs.

2. Program managers and staff personnel from Air University.

3. Staff personnel from HQ ATC (DO), Randolph AFB (pilot training).

4. Instructors and staff personnel from Undergraduate Navigator Training (UNT), Mather AFB.

3.4 DATA COLLECTION

The necessary survey data were collected at each of the sites identified as part of the user survey sampling. The preferred procedure, observed wherever the participating personnel could accommodate the demands on their time, was as follows:

1. A group of Air Force participants gathered for a 30-minute briefing which explained the purposes of the survey and the meanings of CAI, CMI, and other special terms used in the survey forms.

2. Survey forms were distributed to the participants.

3. Participants completed the survey forms.

4. The survey forms were collected.

The total time required for this procedure averaged approximately 2 hours. Personnel who could not stay for the entire session were permitted to take their survey forms with them to be completed later. In these cases, a representative was designated to collect the forms. Some Lowry TTC personnel were already familiar with AIS computer-based training, and the briefing was omitted. Using these procedures, the rate of return for survey forms was better than 96%.

For some training programs, other than resident technical training, the survey forms were not deemed appropriate. In these cases, the participants were interviewed to determine their particular functional requirements for a computer-based training system.

3.5 DATA ANALYSIS PROCEDURES

The response data--ratings of payoff potential for the CAI/CMI functions extracted from the completed survey forms--were entered into the AIS computer. Then, for each item in the listing of functions, mean payoff ratings and distributions of ratings by groupings of respondents were derived. The grouping of principal interest for the design phase of this study was "all ATC resident technical training respondents." Groupings of ATC respondents involved with training programs other than resident technical training were of interest in determining the extent to which the low-cost system would be able to meet the needs of other types of Air Force training.

The various groups included in the survey differed in size, ranging from 1 to 23 participants per group. It was assumed that all groups were of equal importance and should contribute equally to the mean payoff ratings. Therefore, means were derived for each function by averaging the means from each group entering into the analysis. Thus, the size of a group did not determine that group's contribution to the overall mean ratings.

3.6 DETERMINATION OF FUNCTIONAL REQUIREMENTS

The user ratings of the CAI/CMI functions and the system impacts of those functions were two prime considerations in determining the functional requirements for the low-cost system. The end product was a listing of CAI/CMI functional requirements plus a recommendation for each function that it be either retained as a function to be provided by the low-cost system or eliminated from further consideration.

3.6.1 Results From Resident Technical Training

A total of 268 personnel involved in resident technical training completed forms for the survey of user functional requirements. The distribution of participants is shown in Table 1.

The results from the survey of ATC resident technical training programs are shown in Appendixes C and D. Appendix C lists the functions in the order in which they appeared on the survey forms and indicates the mean payoff ratings and the system impacts (files needed and estimated CPU usage) for each of the functions. Appendix D lists the functions in order of average estimated payoff, and includes the distribution of ratings given to the functions by the survey participants.

The user survey results can be summarized as follows:

1. Mean ratings of the 184 functions range from the highest-rated item (Flag Test Item Alternatives Missed by More Than 70% of Students) with a mean rating of 2.07, to the lowest-rated item (Students Select Desired Alternate Module Assignments) with a mean rating of 3.71.

2. Of the 184 listed functions, 61 received average ratings better than 2.50, and 115 received average ratings less than 2.50 but better less 3.00. Only 8 of the functions rated worse than 3.00 (moderate payoff).

3. Eighty-two of the functions were rated 1 (very high payoff) or 2 (high payoff) by 50% or more of the 268 participants.

4. Even the lowest-rated functions (Students Select Alternatives, and Heuristics Rules For Assignment Selection) were rated high or very high payoff by more than 7% of the participants.

TABLE 1. RESIDENT TECHNICAL TRAINING PROGRAMS AND NUMBERS OF PEOPLE SURVEYED

LOCATION/PROGRAM	INSTRUCTORS	SUPERVISORS	TOTALS
SHEPPARD TTC			
Air Cargo Specialist	9	8	
Disbursement Accounting	3	5	
Faculty Development	11	10	
Health Care Sciences	9	10	
Total			65
KEESLER TTC			
Ground Radio Repairman	7	7	
Personnel Specialist	9	6	
Faculty Development	-	4	
Telecommunication Specialist	5	4	
Total			42
CHANUTE TTC			
AGE Repairman	8	15	
Vehicle Repairman	15	3	
Life Support Specialist	4	7	
Aircraft Pneudraulics	10	3	
Airframe Repair Specialist	5	4	
Plans and Requirements Div.	-	6	
PLATO Development Group	-	4	
Total			84
LOWRY TTC			
Inventory Management	9	1	
Materiel Facilities	6	-	
Precision Measurement Equip.	15	5	
Inventory Mgt. Specialist	5	-	
Munitions Maint. Specialist	-	4	
Weapons Mechanic	5	4	
Faculty Development	3	6	
Total			63
RANDOLPH AFB (HQ ATC)			
Technical Training (TT)	-	11	
Plans (XP)	-	3	
Total			14
TOTALS	138	130	268

5. The highest-rated functions (Flag Alternatives Missed By More Than 70%), was rated no payoff by only one of the participants.

6. The numbers of X (don't know) responses ranged from 4 (for On Line Test Capabilities) to 55 (for CAI Authoring Editor Automatically Structures Sequencing Of Frames).

Mean ratings and correlations between ratings from the various resident training organizations involved are shown in Table 2. The overall mean ratings range from 2.91 (slightly better than moderate payoff average for the 184 functions) at Lowry up to 2.48 (midway between moderate and high payoff) at Keesler. The correlations are all positive and range from 0.30 for Lowry/Randolph up to 0.78 for Sheppard/Keesler. There is moderate agreement between organizations in their ratings of the functions and quite close correspondence between organizations in their overall mean ratings. In other words, the organizations showed moderate agreement as to which functions were most, and least, important, and agreed rather closely as to the potential payoff of CAI/CMI for their particular training operations.

TABLE 2. MEAN RATINGS FROM RESIDENT TRAINING ORGANIZATIONS AND CORRELATIONS BETWEEN ORGANIZATIONS

LOCATION	MEAN RATING	CORRELATIONS			
		KEESLER	CHANUTE	LOWRY	RANDOLPH
SHEPPARD	2.50	.78	.57	.41	.39
KEESLER	2.48		.43	.36	.44
CHANUTE	2.62			.63	.33
LOWRY	2.91				.30
RANDOLPH	2.78				

Mean ratings from personnel with and without CBI experience at Lowry and at Chanute are shown in Table 3. These comparisons are of interest in determining if experience with CBI results in any overall change in how the payoffs of CAI/CMI functions are viewed. At Lowry TTC, the average rating from personnel in AIS courses was 2.70, somewhat better than the 3.13 average for personnel in the non-PLATO courses. At Chanute, the overall mean rating from personnel in PLATO courses was 2.37, somewhat better than the overall mean of 2.58 from personnel in the non-PLATO courses. It appears that experience with CBI did not markedly affect the mean ratings of CAI/CMI functions.

TABLE 3. MEAN RATINGS FROM PERSONNEL ASSOCIATED WITH COMPUTER-BASED AND NON-COMPUTER-BASED COURSES

WRY TTC

AIS COURSES	MEAN	NON-AIS COURSES	MEAN
ventory Management	2.88	Inventory Mgt. Supvr.	3.46
teriel Facilities	2.51	Munitions Maintenance	3.25
ecis. Meas. Equip.	2.89	Faculty Development	2.69
apons Mechanic	2.52		
Overall Means	2.70		3.13

IANUTE TTC

PLATO COURSES	MEAN	NON-PLATO COURSES	MEAN
:hicle Repairman	3.06	AGE Repairman	2.45
ieudraulics	2.63	Life Support	2.58
.ATO Devel. Group	1.41	Airframe Repair	2.70
Overall Means	2.37		2.58

The last item on the survey forms asked participants to list any dditional functions that should be provided by a computer-based trainng system. There were 57 participants who responded to this uestion. Most of the responses added more detail to already-listed unctions, or commented (positively or negatively) on the survey and on BI. The substantive suggestions for additional functions, and the subequent actions taken, are as follows:

1. System to adjust the honor graduate score to keep within the 10% ATC requirement - Action: to be included in the low-cost system specification.

2. System to provide a data base to handle credit in the Community College of the Air Force (CCAF) for courses completed - Action: not to be included in low-cost system, because of potential interface problems, and because the low-cost system is to be a local system.

3. System to provide dial-up conversational capability between terminals, for student-instructor interactions - Action: not to be included in low-cost system, because of likelihood of

misuse and because the initial low-cost system is oriented toward local resident technical training use, rather than terminals distributed at remote locations.

4. System to assign instructors automatically, within the course, based on qualifications, availability, etc. - Action: not to be included because of unfavorable institutional change aspects and overlap with other Air Force personnel management systems.

5. System to assign graduating students to duty stations, based on student proficiencies/deficiencies and on duty station requirements - Action: not to be included, because of unfavorable institutional change aspects and overlap with other personnel management systems.

Examination of the survey results leads to the conclusion that all f the CAI/CMI functions are of some potential value to resident echnical training. Furthermore, estimates of payoff potential range long a continuum, without clear separation points, from low payoff up o high payoff. The moderate correlations between organizations suggest iverse training needs -- i.e., the subset of functions with the greatst payoff potential for one ATC organization is not the subset with reatest potential for another organization. The system impact stimates shown in Appendix C indicate that file requirements and CPU imes are determined principally by inclusion or omission of major roups of functions, not by inclusion or omission of a few functions rom within a major group. Therefore, even though specific functional equirements differ from program to program, it may be most practical o provide a system which has all desired capabilities and allow the rograms to use those functions they want and ignore others.

As the final step in the analysis of functional requirements for TC resident technical training, AIS experience and lessons learned ere applied in determining the final list of CAI/CMI functions to nter into the system analysis for the low-cost system. The functions hat were dropped from further consideration, and the rationales for mitting these functions from the low-cost system, are listed in Table . The retained functions enter into the system analysis and design hase of this study.

TABLE 4. FUNCTIONS OMITTED FROM THE LOW-COST SYSTEM SPECIFICATION, AND RATIONALES FOR OMISSIONS

FUNCTION (Complete Statements are in Appendix A)/RATIONALE FOR OMISSION

1. IA2 STUDENT TESTING AND EVALUATION - CORRECT SCORE FOR GUESSING/ Rated low in survey of Air Force needs, not viewed as educationally important by ATC personnel.

2. IA3 STUDENT TESTING AND EVALUATION-WEIGHT QUESTIONS DIFFERENTIALLY/ Not practical, in Air Force courses, to determine the weightings. Requires subjective judgements from subject matter experts, or requires a large amount of performance data collected within the course and from the field, with time-consuming data analyses and interpretations to relate responses with field performance. The demand on course personnel to accomplish these tasks is not worthwhile, in terms of educational benefits.

3. IA6 STUDENT TESTING AND EVALUATION-PASS SPECIFIC QUESTIONS/ Rated low by ATC personnel, viewed as low payoff. Determining critical "must answer" questions requires subjective judgements by course personnel, supplemented with data collection and analyses to validate the decisions. The educational returns will not justify the demands on ATC course personnel.

4. IB4 STUDENT TESTING AND EVALUATION-ON-LINE CONSTRUCTED RESPONSES/ The costs of software development for this capability, and the demands made on authors, outweigh the educational gains that can be expected in ATC resident technical training. Authors are required to specify, in great detail, allowable alternate spellings, alternate orderings of words, etc. Only after careful observations of student responses can an author determine that the correct answers are all treated as correct and that all the incorrect answers are scored as incorrect.

5. IB6 STUDENT TESTING AND EVALUATION ON-LINE, ADAPTIVE ON COURSE PERFORMANCE/ Too difficult for authors to define the adaptation to be used. Requires data, and analyses, to relate student performance on other lessons in the course to "what should be done at this step in this test?" The necessary analyses and interpretations are, practically, not cost effective in ATC resident technical training

6. IIB5 STUDENT ASSIGNMENT-ORDER SELECTED BY INSTRUCTOR/ This capability, if provided, would impose on instructors the task of determining the sequence in which each student should take the course lessons. It is more practical to

TABLE 4. (Continued)

have the system make assignments based on criteria determined by the Branch, with instructors overriding for exceptional cases.

7. IIC1 STUDENT ASSIGNMENT-INSTRUCTOR ASSIGNS ALTERNATES/
As for the preceding item, the instructor is freed of routine if the system makes the assignments to alternates, with the instructor overriding for exceptional cases.

8. IIC2 STUDENT ASSIGNMENT-STUDENT SELECTS DESIRED ALTERNATES/
Rated very low by ATC--instructional payoff is believed to be quite small. Omitting this function still leaves the instructors free to override, so that a student who can convince an instructor to intervene may take any desired alternate.

9. IIIB5 STUDENT PROGRESS MANAGEMENT-GRADUATES: SCHEDULE OUT-PROCESSING/
The system will flag those students who are to graduate during some designated time period. However, the problems of interfacing with all of the organizations involved in out-processing students is outside the scope of the low-cost system effort.

10. IIIC6 STUDENT PROGRESS MANAGEMENT-MANAGEMENT TARGETS RELATIVE TO PLAN OF INSTRUCTION LENGTH/
Average course length is more immediately related to curriculum changes than is Plan of Instruction length. Therefore, management functions which are relative to average course length will reflect shortened or lengthened curricula sooner than if relative to Plan of Instruction length.

11. VB4 COMPUTER-AIDED INSTRUCTION (CAI)-TOUCH PANEL OR LIGHT PEN/
Rated low by ATC personnel. Seldom needed for student use. Principal value is in preparation of graphics displays for CAI lessons. This will be accomplished at a graphics terminal, in the low-cost system, rather than at a student interactive terminal.

12. VIIG1 INFORMATION RETRIEVAL AND REPORTS-PRESERVICE EDUCATION, VOC. TRNG., TO MAKE FORECASTS OF FIELD PERFORMANCE/
Difficult to derive predictions based on pre-service vocational education data. Good predictions would require, for each course, a sufficient data base from which to derive reasonably accurate regression equations or heuristic rules, and the skill and time to perform and interpret the analyses.

TABLE 4. (Concluded)

13. VIIG2 INFORMATION RETRIEVAL AND REPORTS-PRESERVICE OCCUPATION AND JOB EXPERIENCE TO MAKE FORECASTS OF FIELD PERFORMANCE/
    Rationale for omission, same as for VIIG1 above.

14. VIIG3 INFORMATION RETRIEVAL AND REPORTS-AF PERSONNEL RECORDS DATA (ASVAB, ETC.) TO MAKE FORECASTS OF FIELD PERFORMANCE/
    Rationale for omission, same as for VIIG1 above.

15. VIIG5 INFORMATION RETRIEVAL AND REPORTS-SPECIALTY-RELATED DEFICIENCIES TO MAKE FORECASTS OF FIELD PERFORMANCE/
    Rationale for omission, same as for VIIG1 above.

16. VIIG6 INFORMATION RETRIEVAL AND REPORTS-PREDICT STUDENTS' ADAPTABILITY, PERFORMANCE, AND PROGRESSION IN OPERATIONAL FIELD ASSIGNMENTS/
    Rationale for omission, same as for VIIG1 above.

NOTE: Of the VIIG set of functions (Performance Forecast Reports to the Field), VIIG4 will be provided by the low-cost system - Reports to the field based on in-service training performance data.

17. VIIH1 SPECIAL REPORTS-BASIC DATA RETRIEVAL, BKGD/
    Dropped in favor of the higher-rated Interactive Retrieval With Statistics (VIIH3).

18. VIIH2 SPECIAL REPORTS-INTERACTIVE RETRIEVAL/
    Dropped in favor of the higher-rated Interactive Retrieval With Statistics (VIIH3).

3.6.2 Results from Other Air Force Training Programs

In addition to surveying ATC resident technical training requirements, other Air Force training programs were also included. The additional programs, and numbers of participants, are listed in Table 5. As described earlier (Section 3.4.1) and as indicated below, data were collected using survey forms and by interviews in which the survey form served as a guide.

TABLE 5. ADDITIONAL PROGRAMS INCLUDED IN SURVEY, AND NUMBERS OF PARTICIPANTS

	INSTRUCTORS	SUPERVISORS
FIELD TRAINING DETACHMENTS & ON-THE-JOB TRAINING--SHEPPARD, MATHER, & DAVIS MONTHAN AFBs		
Survey Forms	23	9
Interviews	2	5
AIR UNIVERSITY		
Survey Forms	-	11
EXTENSION COURSE INSTITUTE		
Interviews	-	8
HQ ATC (DO), RANDOLPH AFB (Pilot Training)*		
Survey Forms	-	1
MATHER AFB (Undergraduate Navigator Training)		
Survey Forms	2	5
Interviews	6	11
TOTALS	33	50

* Explicit definition of the computer-based functions required by Flight Training is given in Data Automation Requirement DAR A78-2, Time Related Instructional Management for Pilot Training, Air Training Command, 29 June 1978.

Results from the survey forms are tabulated in Appendix E. The mean ratings and the correlations between ratings from the various programs are shown in Table 6. Resident technical training is also included in Table 6 for purposes of comparison.

TABLE 6. MEAN RATINGS AND CORRELATIONS FOR VARIOUS AIR FORCE TRAINING PROGRAMS

PROGRAM*	OVERALL MEAN RATINGS	CORRELATIONS			
		UNT	PT	AU	RES
OJT/FTD	2.92	.25	.04	.34	.37
UNT	2.68		.73	.08	.13
PT	3.09			.16	-.08
AU	3.31				.51
RES	2.62				

* On-The-Job Training/Field Training Detachments (OJT/FTD), Undergraduate Navigator Training (UNT), Pilot Training (PT), and Air University (AU). Resident Technical Training (RES) is included for comparison.

The overall mean of the ratings from resident technical training is 2.62 -- between High (2.0) and Moderate (3.0) payoff. The mean rating from UNT is down only slightly (2.68), followed by OJT/FTD (2.92), PT (3.09), and AU (3.31). These other Air Force training programs do see payoff potential in the CAI/CMI functions, but not as much potential as in resident technical training. The correlations indicate some commonality among the needs of OJT/FTD, AU, and resident technical training (correlations of .34, .37, and .51). There is also considerable commonality between navigator training and pilot training (correlation of .73).

The notes from the interviews were analyzed, and the results are shown in Appendix F. Because the survey form served as a guide for the interviews, the responses fall into the seven categories used on the survey form but do not correspond exactly to the wordings used in the survey. Each function listed in Appendix F was categorized as either (a) already provided by the functions listed on the survey form, (b) already provided by the survey form functions but requiring minor modification to adapt from resident technical training (for example, referencing test items to Career Development Course volumes instead of to resident training lessons, or (c) not provided by the survey form functions. These categories are also indicated in Appendix F.

4.0 HARDWARE SURVEYS AND ANALYSES

To provide a framework for configuring a low-cost system, the following training scenario and design goals were established:

1. Approximately 500 students per shift, enrolled in five courses.
2. Not more than 10% of the students using CAI at any one time.
3. An average of five CMI interactions per student per shift.
4. Not more than ten administrative personnel on-line at any one time.
5. Productive response times as follows:
    a. less than or equal to 1 second average response time for simple operations.
    b. less than or equal to 3 seconds average response time for more complex operations.

The training scenario and design goals suggest a probable price range (1979) of $500,000 to $600,000 for mainframe, peripherals, terminals, and associated support hardware.

Surveys of hardware were restricted to selected equipment items in the areas of full size and minicomputer mainframes and peripherals, data processing equipment, terminals, and related communication systems. Equipment was evaluated as to its potential for application in the low-cost system. The survey methods included reviews of literature, trips to remote sites to consider classes of equipment or specific hardware, and visits to trade shows and seminars. The DataPro Research Corp. (1978) and other surveys furnished preliminary reviews of equipment manufacturers' specifications on computer mainframes and peripherals, terminals, communications systems, and software.

4.1 CANDIDATE CPU ARCHITECTURES

The purpose of this portion of the study was to analyze existing computing architectures and to identify one which would provide a cost effective approach to supporting ATC resident technical training programs. To accomplish the initial investigation tasks, current publications on existing computing architectures were examined. Then, considering functional capabilities and acquisition costs, a number of existing computer architectures were selected as an initial set of candidate CPUs for more detailed investigation. Data on the efficiencies of each of the systems were analyzed to determine the best performing CPUs. Then, the criteria of software quality and reliability, hardware reliability, and effectiveness of maintenance service were considered as additional evaluation factors.

Within the framework of the training scenario, design goals, and evaluation factors described above, many large-scale and super computers could fulfill the functional requirements. However, the CPU and input/output (I/O) power they provide are not necessary in this application, and the costs of such machines are above the expected price range. Many smaller-scale computers are priced attractively, but do not provide the necessary power.

In evaluating candidate architectures, millions of operations per second (MOPS) was used as the unit of measurement, rather than millions of instructions per second (MIPS), because the MIPS rating can be misleading. Machine 1 may have a higher MIPS rate than machine 2, but it may take machine 1 more instructions to do a given amount of work. Machine 2 could actually have a MIPS rate that is less than machine 1 and yet accomplish an entity of work in a shorter period of time.

A MOPS figure of 0.15 (150,000 operations per second) and an I/O rate of 24.0 (24 million bits per second) were established as minimums needed to meet the functional requirements for the low-cost system. These figures were arrived at in the following manner. In the current AIS system, the hardware provides functional capabilities that are much in line with the training scenario and design goals described. On the current AIS there are, normally, approximately 500 students, approximately 50 on-line terminals (including CMI terminals), and response times similar to those given previously. Therefore, the capabilities of the current AIS system are known. The CDC 6400 (equivalent to the AIS Cyber 73) which was selected as the benchmark system, yielded MOPS = 0.17 and I/O rate = 24.0. For adequate performance in the low-cost system, a MOPS figure of 0.15 and an I/O rate of 24.0 were determined to be minimums below which unacceptable degradation of performance would result.

After evaluating the candidate CPUs, the Digital Equipment Corp. (DEC) VAX 11/780 was selected for purposes of developing a system design and cost analysis for the low-cost CAI/CMI system. Although this is not the only CPU that will meet the functional requirements for the low-cost system, the VAX 11/780 serves as the example CPU in subsequent sections of this study.

If the functional capabilities required of the low-cost system were reduced, some corresponding decrease in computing power (and in CPU cost) could be realized. For example, if it were desired to support the same students but with terminal response times of 10 seconds instead of the faster times assumed as goals for the low-cost system, then a less capable CPU could be chosen. It should be kept in mind, however, that the mainframe represents only about 15% of the cost of the system. Reducing the computational capability of the system would reduce the cost, but the responsiveness of the system would also be reduced. For these reasons, it is more cost effective to choose a system which will yield the higher level of productivity at a small increase in cost. The terminals represent about 50% of the cost of the system. Major cost reductions can only be achieved by eliminating major areas of capability (CAI or CMI, for example), thereby reducing the cost for terminals.

4.2 SURVEY OF INTERACTIVE TERMINALS

The capabilities required from interactive terminals by students, authors, instructors, and other administrative personnel were analyzed. Administrators need alphanumeric (text) presentations, principally, and have very little need for any additional capabilities. Preparation and presentation of CAI lessons, and on-line preparation of materials for off-line presentation, also rely principally on alphanumeric text capability. However, there are some content areas and special presentations which will benefit from color and graphics capabilities. In general, CAI programs require upper and lower case characters, numbers, and punctuation from the American Standard Code for Information Interchange (ASCII) set, and a -next- key for student control over the program. Programs for CMI have the same requirements, plus needs for additional function keys (-back- and at least three additional function or control keys).

The attributes of some 300 alphanumeric display terminals and graphics terminals were reviewed for similarities and for industry-wide standard features. The results (below) indicate constraints within which the low-cost system will have to be designed if off-the-shelf terminals are to be used. The relative merits of various terminals were evaluated, and candidate terminals are recommended for use by students, authors, and administrators in the low-cost CAI/CMI system.

4.2.1 Display Format

A format of 80 characters per line is standard for most terminals. Alphanumeric terminals commonly provide 24 or 25 lines, and graphics terminals commonly provide 34 or 48 lines. Most terminals provide as standard either 64 different displayable characters (numbers, upper case alphabet, and limited punctuation), or the standard 96 character ASCII set (numbers, upper and lower case alphabet, and extra symbols). The 96 characters are considered necessary for the text requirements of the low-cost CAI/CMI system.

Symbols are formed within a dot matrix on all the terminals. Characters using higher resolution formats are generally more readable, especially for such characters as "m" and "w." Lower-case letters are easier to read when the descenders for the characters "g," "j," "p," "q," and "y" extend below the matrix used with capitals and numbers.

The low-cost graphics terminals reviewed have a picture element (pixel) of resolution which is some fraction of a one-character matrix. The range of resolution standardly available ranges from the lowest, 160 pixels horizontally by 192 pixels vertically, up to the highest resolution, 640 horizontally by 476 vertically.

Many programs used on the low-cost CAI/CMI system would benefit from some accenting method for portions of the programs--lines to serve as separators in CMI editors or to box in accented words for CAI programs, for example. Most of the low-cost alphanumeric terminals did not provide line drawing capabilities, but some provide either two brightness levels, or the capability to reverse the character video for individual fields. Words, sentences, or phrases can be put into foreground or background by using one of the two methods. The terminals considered as candidates for the low-cost system have at least one of these two features available.

All programs are expected to send an X-Y coordinate to position the start of words or phrases, or to echo characters back to the user. Therefore, candidate terminals should have addressable cursors. There is no standard practice for setting the X-Y position. Various sequences are used to initialize the cursor setting mode, and different values are sent to the terminals in either X first or Y first order to set the coordinates.

An additional requirement is that both alphanumeric and graphics terminals must have the ability to erase the screen on command from the computer and from the terminal user. All terminals reviewed had bulk screen erase, and most could erase to the end of line or the end of the screen from the cursor position.

4.2.2 Transmission Speed

A transmission speed of approximately 120 characters per second is recommended when intermixing upper and lower case alphabet and numbers. Transmission of ASCII codes over communication lines requires the electronic formatting of the eight bit ASCII code between a start and a stop bit. To transmit 120 characters per second, at least 1200 bits per second must be received at the terminal. All terminals considered for the low-cost system were able to receive data in a switch-selectable range of 110 to 9200 or more bits per second, and all included the 1200 bits per second rate. All the terminals included electronics to receive or send data using an RS-232C interface to a modem or data concentrator.

4.2.3 Other Transmission Parameters

To give the computer complete control over the characters returned to the terminal, and to provide for data integrity of the user's input to the computer, full duplex transmission should be used. In full duplex, each character code is sent to the computer as soon as a key has been pressed. The computer stores the single key value and returns for display either the same code or some other code which is program controlled. For example, during log on, a computer may not return the password for display but may instead return a special character.

Full duplex also speeds up verification of data received by the computer. Half duplex transmission, not recommended for the low-cost system, customarily places the keyboard character on the screen directly, and in parallel sends the character code to the computer. The computer does not return a character, so the user cannot verify that the computer has received the transmission as it was entered at the terminal.

Full duplex character-at-a-time mode also implies that data are sent asynchronously, with no need for synchronization with the network processing unit.

4.2.4 Keyboard

All terminals reviewed has a standard typewriter keyboard, with letters positioned in the standard QWERTY sequence. A special requirement noted for the low-cost CAI/CMI system programs is that a function key method should be available to send special non-display character commands to the central computer for CAI or CMI program or editor control. Most of the low-cost terminals include a numeric pad and some provide a number of function keys. Most of the keyboards provide a control key, so that special functions can be simulated by non-displayable control characters even if no function keys are available.

4.2.5 Interactive Terminal Selection

Final selection of interactive alphanumeric terminals must be based on specific user needs and applications. The described functions are considered essential in any selection for a low-cost CAI/CMI system. To configure an example low-cost system, the results from the foregoing survey were used in selecting candidate alphanumeric and graphics terminals which meet the functional requirements. However, these are not the only terminals which could satisfy the requirements. The candidate terminals for the example low-cost system are as follows:

1. Alphanumeric text terminal for students, instructors, and administrators--ADDS Regent 100 terminal.

2. Text/limited resolution graphics/color terminal for students--Intecolor 8001G terminal with lower case and function keys.

3. High resolution graphics terminal for student use--Tektronix 4025 terminal with 8192 words of graphic memory.

4.3 MANAGEMENT DEVICES

A wide variety of devices can serve to accomplish the required CMI functions. In fact, if keyboard input for data is sufficient and if hardcopy output is not needed, the student terminals can accomplish the CMI functions. The configuration of management devices which can best serve the needs of a low-cost system installation will depend on such factors as the following:

1. Types of input to be handled--manual input from keyboard, pencil-marked forms, pencil-marked cards, badges, off-line response devices, etc.

2. Types of output required--hardcopy output, display at interactive terminal, specialized displays, etc.

3. Quantity of input and output to be handled--number of students, frequency of interaction, amount of information handled at each interaction, etc.

4. Instructional and administrative decisions--procedures for registration, absence reporting, testing, prescribing instruction, managing student progress, etc.

In order to configure an example system without knowing the characteristics of the installation environment, it is assumed that capability approximately equal to the current AIS management devices will be required. Each of the management devices in the example system will therefore consist of a forms reader, a line printer, and the electronics to interface with the computer. However, the management devices needed for a specific installation site should be determined by analyzing the needs of that particular site. Considerable cost savings might be realized if simpler management devices are adequate for the CMI capability required at a site.

4.4 COMMUNICATIONS NETWORK

The communications network is considered to be the equipment necessary to connect terminals to the communications processor. This section reviews various methods of transmitting data between a host computer and one or more terminals at distances up to 5 miles, the maximum expected between buildings for the low-cost CAI/CMI system. It is assumed that dedicated lines would be used on an Air Force base.

Equipment now available provides for standard data format and allows for transmission of such data over voice grade telephone lines. The ASCII protocol (line discipline, control code sequence or data format) has been widely accepted by government and industry as a communications standard. A system using modern data communications formats and transmission media holds the promise of long range compatability and expandability between CPUs and terminals.

The communications system for the low-cost CAI/CMI system must provide for asynchronous full duplex data transmission to each terminal at 1200 bits per second (a standard speed corresponding to 120 characters per second) to allow for immediate character by character echo to the terminal display. Asynchronous operation describes another factor in data transmission--the system can transfer data at the user's random rate. Full duplex describes the communications system as having simultaneous communications both to and from the terminal, similar to a telephone conversation between two parties.

Modern approaches to data communication involve the use of readily available telephone circuits. The most promising options available are to provide one or more dedicated line pairs from the central computer site to the terminals. Additional line amplifiers and correction of phase differences are not required since the overall distance between the central computer and any terminal is expected to be under 5 miles. Standard telephone pairs as presently in use with the AIS system are expected to be available for the low-cost CAI/CMI system. Full duplex operation requires a pair of two-conductor telephone lines to provide a continuous communication link in both directions between computer and terminals.

The two sections following describe line modulation techniques for handling data between the central computer and the terminals. The first section discusses single modems for communicating with single stand-alone terminals. The second discusses the recently developed statistical multiplexer systems which permit operation of multiple terminals on single communication line pairs.

4.4.1 Transmission to Single Terminals

Most host computer-related hardware can transmit data to terminals at distances up to about 200 feet. However, terminals located at greater distances should not be operated on lines with raw digital data, because of signal attenuation and susceptibility to noise. In order to transmit data to terminals at longer distances, modem pairs are recommended. Modems provide for conversion of the digital data by frequency shift or phase shift keying of an audio frequency. Applicable types of modems include trunk-line and short-haul types. Both types provide the capabilities required for the low-cost CAI/CMI system, including full duplex asynchronous modes, diagnostics, and interconnection to standard RS-232C electronic interfaces.

Short-haul modems generally accommodate a wide range of transmission speeds and do, therefore, contribute to a system's potential for exapnsion. Speeds typically range from 1200 to 19,200 bits per second and are switch selectable. The price range for short-haul modems is about $690 to $995 per unit. These modems can be used in applications requiring high bit rates, such as some graphics applications, and are good for distances up to 20 miles over unconditioned lines. Trunk-line modems are generally limited in their range of transmission speeds. This type of modem sells in the range of $320 to $525 each, operates at or below 2400 bits per second, is good for long distances (up to several thousand miles), but requires conditioned lines.

The following modems were investigated to determine their capabilities for self-diagnosis in the event of system failure, ease and ability in matching the unit to the telephone lines, and ease and speed of maintenance. All of the listed modems are full duplex, have asynchronous operation and RS-232C interfacing, provide diagnostics, and have a minimum speed of 1200 bits per second.

Trunk Line Modems

Manufacturer	Model No.	Speed (Baud)
Timeplex	202	Up to 2000
Tele-Dynamics	7202T	Up to 1800
Syntech	TT-202	Up to 1800
Novation	202	1200/1800
Penril	1800	Up to 1800

4.4.2 Transmission to Multiple Terminals

Statistical multiplexers (data concentrators) are available off-the-shelf. The units handle sampling based on active users only, without wasting time segments on idle or inactive terminals. The traffic demand is monitored by a statistical algorithm and data are moved according to demand. A pair of inexpensive statistical multiplexers can provide service over 2 telephone circuits to as many as 32 terminals.

Traditional error correction techniques can be applied with statistical multiplexing. In the event that an error occurs in the data format due to a disturbance in the communications sytem, the statistical multiplexer will retransmit the data. The multiplexers can interrogate each other to repeat a message to be sure the message is transmitted correctly.

The statistical multiplexer approach utilizes a pair of statistical multiplexers (one at the host computer and the other near the terminals), two modems, and a pair of two-conductor telephone lines. This configuration will typically handle four or more terminals.

For the statistical multiplexer approach, the modem pair, the communication lines, and the multiplexer line ports are required to operate at only one-half the bit rate of the maximum composite terminal speed. When one to eight 1200 bits per second terminals are connected to an eight channel statistical multiplexer, for example, a channel speed of only 4800 bits per second (8 x 1200/2) is required. The eight channel statistical multiplexer system will operate in a degraded mode while five or more terminals are all receiving data at the same instant. Short-haul modems are preferred because of their ability to operate at faster speeds at the flip of a switch.

System expansion up to the capacity of the multiplexer involves considerably less cost than adding modem pairs as in the single terminal system. While it may be necessary to purchase add-on channel cards to expand, it is not necessary to purchase modems and lines to service another terminal. For the low-cost system with relatively short expected distances from a central computer to terminals, only multiplexer systems for 8 or 16 terminals have been considered so that the maximum line speed will not exceed 9600 bits per second.

The statistical multiplexers and short-haul modems listed in the following tables were investigated to determine their self diagnostic capabilities, ease and speed of maintenance, and ability to easily match characteristics to the telephone lines. A pair of multiplexers and a pair of modems are required for a system. The first item in each list was selected for the example low-cost system.

Statistical Multiplexers

Manufacturer	Model No.	Max No. of Terminals
Digital Communications Associates	Smart/Mux 115	16
Infotron	Supermux 480	8
Micom	800	8
Timeplex	M-8	8

Short Haul Modems

Manufacturer	Model No.
Syntech	LDM-7296
Tele-Dynamics	7300
Paradyne	SRM-192
Codex	8200 LDSU

5.0 SOFTWARE SURVEYS AND ANALYSES

5.1 SUPPORT SOFTWARE

Support software can be defined as all of the software supporting the operation of the low-cost system except the instructional (CAI and CMI) software. It includes the operating system, file manager, loaders, linkers, additional compilers, assembler, and utility routines.

Support software for one system is rarely executable on another system because of machine dependencies. Therefore, support software is not an area of system capability which should be evaluated in isolation from the CPU. Rather, the capability of support software is one criterion to be considered in selecting a CPU. If possible, the CPU manufacturer's support software should be used, instead of creating special purpose software or modifying the manufacturer's software. This is advantageous for the following reasons:

1. The manufacturer is obligated to perform maintenance on the support software, thereby relieving the user of this responsibility.
2. Manufacturers often make improvements to their support software. As reasonable requests from the user community are received, a manufacturer often implements the enhancements, and makes the improvements available to users. If the support software is not user-modified, new releases of software from the manufacturer will not require modification, thereby saving effort in acquiring upgraded support software.
3. If the instructional software can execute without being heavily dependent on special purpose software, advantage can be taken of advances in hardware technology and/or lowered hardware costs by readily transferring to an attractive new system. For example, if the execution of the instructional software requires the services of a special purpose operating system, then the instructional software is heavily dependent on that operating system. Moreover, the instructional software cannot be readily transferred to a new system if the target machine does not support the language in which the operating system is coded. On the other hand, if the execution environment provides standard interfaces to manufacturer supplied operating systems, then the instructional software can be readily transferred to a new system.

The support software for the example CPU (the DEC VAX 11/780) was evaluated, and appears to have all of the capabilities required for the low-cost system. It is therefore used as the support software for the example system configuration.

5.2 PROGRAMMING LANGUAGE

Evaluating a programming language to determine its merit is a subjective process. Factors entering into the evaluation of a language can be conflicting. For example, a language with many available features could be deemed powerful and therefore "good"--or, because of its many features, the same language could be viewed as overly complex and verbose. The main difficulty is that a language is not "good" or "bad" in absolute terms. Previous work in programming language evaluation has shown that the merit of a programming language should be determined with respect to (a) the application area for which it will be used (in this case, CMI and CAI applications) and (b) the computing environment in which the language will appear (the hardware equipment, the fiscal resources, and the personnel available).

5.2.1 Top Level Language Goals

Definition of the goals for a programming language should begin by considering the application area and previous research into what qualities make a language good. Then, by examining the stages of the program development process with respect to the application area, and identifying the most important objectives for a language at the various stages, the top level goals can be defined.

In the CAI/CMI application area, the stages of the program development process are problem specification, design, coding, debugging, and maintaining. In this context, the following top level goals for the low-cost CAI/CMI system programming language are established:

1. Ease of Writing CMI--Some capabilities are particularly important in the design and coding stages of CMI programming. These include (a) allowing adequate record and file handling capabilities for student data, (b) supplying student prescription and pacing constructs, and (c) providing classification and typing of data and execution paths.

2. Ease of Writing CAI--Some capabilities are particularly important in the design and coding stages of CAI programming. These include (a) student response judging and analysis, (b) easily created and displayed screen frames, and (c) easily created questions and decision branching.

3. Reliability--The reliability goal is applicable during coding, debugging, and maintaining. A language is reliable if it facilitates writing correct programs. Compile time checking, execution time checking, program testing features, and program debugging features are factors contributing to this goal.

4. Ease of Learning--Ease of learning is applicable to all the stages of program development. It encompasses uniformity of

syntax and context consistency. Unnecessary complexity of syntax and semantics should be avoided. A fairly common set of constructs should be utilized, supporting as few linguistic concepts as possible. For example, x = 1 is a construct that could also be used in the iterative construct

```
FOR x = 1 STEP 1 TO 10 DO (    ).
```

The language should not contain inconsistencies or context dependencies (e.g., a language that allows int = 1 where "int" is of type integer, but does not allow stng = "ABCD" where "stng" is of type string, is inconsistent in the area of assignments).

5. Maintainability--The maintainability goal is applicable in the debugging and maintaining stages. A language that supports maintainability provides readability, ease of source statement change, and easily constructed source statements.

6. Efficiency--Efficiency is relevant in the coding, debugging, and maintaining stages. The efficiency of a language can be measured by comparing the code the compiler generates (with respect to storage and speed) to that produced by a good assembly language programmer.

5.2.2 Candidate Languages

Surveys of existing programming languages (Sammet, 1978; Brahan, 1973) were used to determine the set of languages which might possibly meet the top level language goals. Languages which could not possibly meet the goals (e.g., those designed for structural engineering or linear programming) were eliminated. Also, languages which might meet the goals but were not currently implemented on at least one computer were eliminated. Languages which have never been implemented, or were once implemented but are no longer supported, were considered to be too costly to make operational. The resulting set of candidate languages is listed below:

ALGOL 68	- A powerful, general purpose, extensible language used to solve a large number of programming problems.
BASIC	- A very simple language used primarily in solving numerical problems, but with some advanced features.
CAMIL	- A general purpose interactive language used for CAI/CMI, systems, and application programming.
COBOL	- An English-like language used primarily for business data processing problems.

CORAL66 - A general purpose language used primarily for solving algebraic problems.

COURSEWRITER III - A simple language used for preparing CAI courses.

FORTRAN - A language designed primarily for numerical computation but used in many other problem areas.

JOVIAL - A language designed primarily for numerical computations and data processing.

NATAL - A course-authoring language used in the preparation of CAI materials.

PASCAL - A general purpose programming language.

PILOT - A simple language for preparing CAI materials.

PLANIT - A language (embedded within a system) for preparing and presenting on-line individualized instruction.

PL/I - A general purpose language used to solve a large number of programming problems.

TAL - An authoring language used to present CAI materials.

TUTOR - A language used for preparing computer-based educational materials.

5.2.3 Minimum Language Features

Language features were determined by examining the necessary CAI/CMI functional capabilities from Appendix C and determining a set of suggested features for accomplishing those capabilities. Appendix G lists the CAI and CMI functions and shows the language features to implement each function. From Appendix G, it is possible to determine (a) which language features could be eliminated as functional capabilities are eliminated or (b) which functional capabilities might have to be eliminated as certain language features are eliminated. The 26 language features are as follows.

1. Built-in data types of:

    INTEGER - e.g., 1, 10, 15
    REAL - e.g., 1.5, 6.10
    LOGICAL - TRUE, FALSE
    STRING - e.g., "ABCDE"
    ARRAY - e.g., ary(1) = ary1(x)
    RECORD - e.g., rec.x=3
    CLASS - e.g., class(c1,c2,c3)

SET - e.g., x ∈ set1
TEXT - long strings of textual data convenient for representing large volumes of data (up to a screen page).

2. Support of variable data - It is necessary to allow data to take on many values throughout the execution of a program. Many programs representing CAI/CMI functions need this capability. An example from PASCAL is:

```
x:=10;
.
.
X:=Y.
```

3. Support of constant data - It is necessary that some data remain constant throughout execution of a program. An example from CAMIL is:

```
DEFINE INTEGER x=5; X cannot be changed within this program.
```

4. Explicit declaration of variables and constants - It is desirable that variables and constants can be declared within a program prior to use. This practice is commonly accepted as contributing to the creation of reliable software. An example from PL/I is:

```
DECLARE I FIXED INTEGER.
```

5. Definition of procedures (subroutines) and functions (procedures that return a value) - Capability to define procedures and functions is needed. This allows the CAI/CMI programs to be modular and therefore reliable and maintainable. An example from PASCAL is:

```
PROCEDURE CALC (INVAL:INTEGER);
 BEGIN
  .
  procedure body
  .
 END.
```

6. Specification of user-defined data types - It is convenient to have built-in, expandable, user-defined data types for use throughout programs. This feature allows creation of different types of data beyond the built-in data types. An example from CAMIL is:

```
TYPE PACKED RECORD (INTEGER I; NUMBER N) RECTYPE.
```

7. Packing data within records and arrays - It should be possible

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to specify packing data within records and arrays to preserve space. See feature 6 for an example of a packed record.

8. Automatic allocation and access for Indexed Sequential files - It should be possible to specify a record or group of records to begin reading or writing by supplying a key for record positioning. This feature is necessary for efficient manipulation of student data on disk.

9. Automatic allocation and access for Direct Access files - It should be possible to position to a particular record by specifying its location on disk. This feature is necessary for efficient maintenance of student data on disk.

10. File sharing - It should be possible for many processes, simultaneously active on the CPU, to access the same disk data file. This feature is necessary for efficient manipulation of student data on disk.

11. Record reservation - It should be possible for a process to lock out all other processes while updating a student record on disk. This feature is necessary for reliable maintenance of student data on disk.

12. IF THEN ELSE construct - Conditional branching (choosing alternate program paths) should be possible. An example from PASCAL is:

```
IF X< >Y THEN Z:=A ELSE Z:=B.
```

13. Iterative statement construct - Loops should be possible within programs using an iterative construct. Many of the CAI/CMI functions will be implemented with program loops. An example from FORTRAN is:

```
DO 10 K=1,10
 .
 loop body
 .
 .
10 CONTINUE.
```

14. N-way conditional branching - It is necessary to be able to choose one alternate out of many to implement many of the functions. An example from CAMIL is:

```
CASE x OF
 BEGIN
 1 y ← 10;
 2 z ← 15;
```

```
  5 a ← 5;
 END.
```

15. Assignment statement - It must be possible to assign values to variables within the language. This feature is necessary for virtually all functions. An example from JOVIAL is:

```
A1 = A1 + 1$.
```

16. Program interrupt detection - A construct is needed to allow for user interruption of the normal program flow. This feature is necessary for programs implementing CAI functions. An example from CAMIL is:

```
ON F1 DO
 BEGIN
  .
  handle the function key interrupt
  .
 END.
```

17. GOTO statement - An unconditional branching statement is needed in the language. This is necessary to transfer to specified sections of code. An example from BASIC is:

```
GO TO 5.
```

18. Communication with CMI terminals - The language must be capable of directing output to and receiving input from CMI terminals. Many CMI functions require this feature.

19. Communication with CAI terminals - The language must be capable of directing output to and receiving input from CAI terminals. Many CAI functions require this feature.

20. Arithmetic operations - The functions of addition, subtraction, multiplication, division, exponentiation, absolute value, modulus, random number generation, sine, cosine, tangent, cotangent, square root, string concatenation, and integer shifting should be available for use in CAI and CMI functions. An example from PASCAL is:

```
X:= Y/2.
```

21. Relational operations - The operations of equal, not equal, less than, greater than, less than or equal, greater than or equal, and set membership must be supported. CAI and CMI functions use these operations. An example from CAMIL is:

```
IF x  ≤  y THEN z ← 10.
```

22. Logical operations - The operations of not, and, or, exclusive or, set complement, set intersection, and set union must be supported, for use in CAI and CMI functions. An example from ALGOL68 is:

```
IF X ≤ 10 ∧ Y ≥ 5  THEN  Z ← 25.
```

23. Interactive terminal page oriented textual communication - It must be possible to display textual information by the page at an interactive terminal via the language. CAI functions require that text be displayed at student terminals.

24. Terminal graphics - A basic line drawing capability which can be utilized to construct terminal graphics should be resident within the language. CAI functions may require this feature.

25. Hardcopy support - It must be possible to interface with a hardcopy printer for generating reports, program listings, and other documents. CAI and CMI functions require this feature.

26. Magnetic tape capability - It is necessary to maintain large volumes of student data on an inexpensive backup medium. By using magnetic tape, areas of more expensive high-speed disk storage can be freed of student data.

5.2.4 Nontechnical Criteria

While the technical merit of a language is of primary importance, certain non-technical criteria should also be considered in determining the cost of implementing the CAI/CMI functions in that language. These criteria are as follows:

1. Language availability on recommended hardware - if a candidate language is not implemented on the host computer, there is a cost associated with making the language's compiler operational on the system.

2. Quality of candidate language documentation - This will have a bearing on how quickly the software can be developed.

3. Availability of trained programmers - If there are no trained programmers available for a candidate language, the cost of implementing the software in this language will be higher.

4. Availability of programs providing required CAI/CMI functional capabilities in a candidate language - If software to implement CAI/CMI functional capabilities already exists in a candidate language, then, with respect to this criterion, the cost of using that language will be decreased.

5.2.5 Language Evaluations

To assist in evaluating candidate languages for the example low-cost system, an approach developed by Brosgol, Hartman, Nestor, Roth, and Weissman (1977) can be utilized. This is an excellent approach for forcing evaluators to think as objectively as possible about the subjective process of evaluating a programming language. In this approach, a rating matrix R, an application vector A, and an intermediate vector I are used in conjunction with a language vector for each candidate language to derive a technical merit score. The technical merit score and four management evaluation scores for a language are entered into a language score vector which, in conjunction with a language management vector, yields a final score for each candidate language. The following paragraphs describe this approach, and suggest suitable parameters for use in evaluations for the low-cost system.

Matrix R is a 26 by 6 matrix whose rows represent the language features (section 5.2.3) and whose columns represent the top level language goals (section 5.2.1). Each matrix element, Rij, is a numeric value indicating the extent to which language feature i contributes toward accomplishing language goal j. The application vector is a column vector of 6 entries representing the relative contributions of the top level goals toward the CAI/CMI application area. After determining R and A, then R x A produces a column vector I with 26 entries, each entry representing the contribution of a language feature toward the application area.

Each entry in the rating matrix R is a value between 0 and 10, indicating how much language feature i contributes toward accomplishing language goal j. The range 0 to 10 is chosen to allow the final technical merit values to fall in the range of 0 to 150 (the maximum technical merit score is actually 149.54). This range could be greater or less and still be representative of the technical merit of a language. However, 0 to 150 is a reasonable range to work with, since technical merit values are then neither unduly large nor extremely small. The suggested rating matrix R, for evaluating languages for the low-cost system, is as follows:

$$
\begin{array}{cc}
 & \text{goals} \\
\begin{array}{c}
\\ \\ \\ \\ \\ \\ \\
\text{f} \\ \text{e} \\ \text{a} \\ \text{t} \\ \text{u} \\ \text{r} \\ \text{e} \\ \text{s} \\
\\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\
\end{array}
&
\left[\begin{array}{cccccc}
8 & 8 & 7 & 6 & 7 & 4 \\
10 & 10 & 8 & 6 & 8 & 5 \\
2 & 2 & 7 & 5 & 5 & 4 \\
3 & 3 & 9 & 5 & 7 & 4 \\
8 & 8 & 8 & 7 & 8 & 5 \\
7 & 5 & 8 & 7 & 8 & 5 \\
7 & 6 & 2 & 4 & 7 & 8 \\
8 & 5 & 5 & 2 & 6 & 8 \\
4 & 2 & 5 & 1 & 4 & 8 \\
8 & 5 & 0 & 0 & 8 & 9 \\
8 & 4 & 10 & 0 & 9 & 0 \\
9 & 9 & 7 & 7 & 7 & 7 \\
9 & 9 & 7 & 7 & 7 & 8 \\
8 & 8 & 8 & 7 & 7 & 9 \\
10 & 10 & 5 & 7 & 8 & 8 \\
0 & 8 & 3 & 5 & 4 & 7 \\
1 & 1 & 0 & 1 & 0 & 6 \\
10 & 0 & 7 & 5 & 7 & 7 \\
0 & 10 & 7 & 7 & 6 & 6 \\
8 & 8 & 6 & 5 & 6 & 6 \\
9 & 9 & 7 & 5 & 6 & 6 \\
6 & 6 & 7 & 5 & 6 & 6 \\
0 & 10 & 7 & 6 & 7 & 6 \\
0 & 8 & 2 & 4 & 2 & 4 \\
7 & 2 & 3 & 4 & 6 & 5 \\
8 & 0 & 0 & 0 & 8 & 8
\end{array}\right]
\end{array}
$$

The application vector A is a column vector of six entries, each entry value reflecting the contribution of a top level language goal toward the CAI/CMI application area. The vector entries must sum to 1.0, and reflect the judged importance of a goal with respect to the application area. Entries should avoid placing too much importance on potentially overlapping goals (e.g., reliability, learnability, maintainability). The recommended entries for application vector A are

$$
\left[\begin{array}{c}
.18 \\
.18 \\
.18 \\
.14 \\
.16 \\
.16
\end{array}\right]
$$

Since the entries in R represent the contributions of the language features toward each of the top level language goals, and since the entries in A represent the contributions of each top level language goal toward the CAI/CMI application area, then R x A produces a column vector I with entries representing the contributions of the language features toward the application area. The product of the recommended vectors, R x A, is

$$\begin{bmatrix} 6.74 \\ 7.96 \\ 4.12 \\ 5.16 \\ 7.38 \\ 5.38 \\ 5.66 \\ 5.76 \\ 4.04 \\ 5.06 \\ 5.40 \\ 7.72 \\ 7.88 \\ 7.86 \\ 8.04 \\ 4.44 \\ 1.46 \\ 6.00 \\ 5.96 \\ 6.58 \\ 7.12 \\ 6.04 \\ 5.98 \\ 3.32 \\ 4.48 \\ 4.00 \end{bmatrix}$$

A language vector CLi is then produced for each candidate language. The entries in the language vector indicate the extent to which the language features are provided. The product CLi x I will then produce a score indicating the technical merit of the language with respect to the CAI/CMI application area. These scores, ranking the technical merits of candidate languages with respect to the CAI/CMI application area, can then be used in management evaluations to arrive at a candidate language recommendation.

The jth entry of language vector CLi indicates how candidate language i contributes toward the jth language feature. For each language feature, the "degree of compliance" for a candidate language must be estimated. A suggested approach for making these estimates is as follows:

T : The language totally meets the requirement. A score of 1.0 will be recorded in the language vector.

P : The language partially meets the requirement. A score of from 0.1 to 0.9 will be recorded in the language vector according to the degree the requirement is partially fulfilled.

F : The language fails to meet the requirement. A score of 0.0 will be recorded in the language vector.

U : It is unknown from the available documentation whether the requirement is satisfied or not. A score of 0.0 will be recorded in the language vector since poor documentation should be considered even if the feature is implemented but not documented.

After CLi is established, the technical merit, TMi, of a candidate language with respect to the CAI/CMI application area can be calculated:

TMi = CLi x I.

Development costs for implementing the CAI/CMI software must be considered. Costs can be categorized as follows:

1. Acquiring the implementation language.
2. Training the programmers in the given language.
3. Designing the system.
4. Coding the system in the given language.
5. Testing, debugging, and verifying the system.
6. Maintaining and upgrading the system.

The entries in a Language Management vector, LM, reflect the contributions of technical merit and of the nontechnical criteria to lowering system development costs. The recommended LM vector is

Technical merit	.33
Language availability on recommended hardware	.25
Quality of documentation	.05
Availability of trained programmers	.06
Availability of instructional software in the language	.31

A five-entry Language Score row vector, LS, whose entries are scores ranging from 0 to 100, is established for each candidate language. Each entry in LS describes how well a candidate language is judged to contribute toward the entries of LM. The first entry in LS is the technical merit score for the language, translated to a 0 to 100 scale. The other entries in LS are determined by examining a) the languages implemented on the candidate hardware system (for purposes of this example system, the VAX 11/780), b) the available language documents, c) the availability of trained programmers, and d) the required CAI/CMI functional capabilities for possible existing implementation by candidate languages. This product LS x LM is the final score for a candidate language.

Clearly, selecting a language for CAI/CMI application involves a considerable amount of subjectivity. However, if the foregoing procedures are followed, the evaluation process is made visible, the numbers entered into the process are open to inspection, and the results can be accepted or rejected on their merits. Also, the evaluation process is designed to allow change to the vector values (the process could easily be automated). In this way, opinions of different individuals can be considered before a final language recommendation is made.

In selecting a language for the low-cost system, the technical and nontechnical merits of the candidate languages should be considered in the context of the defined application area. The evaluation matrix approach just described, or another explicit technique, should be used to reflect the weightings assigned to the technical and nontechnical merits of the languages under consideration. The actual selection must consider specific user applications, program costs, minimum language features, etc. Any language that meets these criteria may be selected.

As part of configuring an example low-cost system, the technical merits of the candidate languages were calculated, relying in some cases on first-hand experience with a language and in other cases on published user literature. The nontechnical criteria discussed previously were also estimated, ending with calculations of final scores for the candidate languages. After application of the matrix approach and the parameters described above, CAMIL was selected for the example system configuration.

5.3 APPLICATIONS SOFTWARE

5.3.1 Applications Programs Required

To implement the CAI/CMI functions, the following types of application software will be required:

1. CMI software --
   - Interface with the interactive terminals.
   - Interface with the management terminals.
   - Validation of forms that are submitted.
   - Scoring of tests (on-line and off-line).
   - Resource management.
   - Assignment selection.
   - Management of students to time targets.
2. CAI software --
   - CAI presentation program.
   - CAI authoring system.
   - Graphics editor.
3. Editor capability to display and modify --
   - Course definition files.
   - Student data files.
   - Test keys.
   - Resource files.
4. Report generation programs --
   - CAI lesson evaluation report.
   - Training management reports.
   - Course Evaluation Summary.

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- Test Item Evaluation report.
- Learning Center rosters.
- Student block progress reports.
- Absence report.
- Homework summary.
- A general data retrieval and report program.

5. Data base support software --
   - An automatic CMI data base validation program.
   - A program to remove student performance data from disk and generate the tape and disk file for the generalized data retrieval program and for the Course Evaluation Summary.
   - A program to remove the CAI data from the disk and generate the tape files for the CAI report programs.
   - A program to remove test item data from the disk and generate the tapes used by the Test Item Evaluation report program.
   - An archiver to remove CAI lessons that are not in regular use from the on-line data base and record them on tape.
   - A program to bring archived CAI programs back as they are needed.
   - An archiver to take programs that are not in regular use from disk and record them on tape.
   - A program to bring archived programs back as they are needed.

5.3.2 Selection of Applications Programs

A number of existing CBI systems were surveyed to determine their capabilities in the applications programs area. All of the existing systems have some elements of capability that can be characterized as CMI, and most have some CAI capability. All of the functional capabilities required for the low-cost system have been implemented on one or more of the existing systems, but no single existing system incorporates all of the capabilities.

A large proportion of the CAI and CMI functional capabilities for the low-cost system are currently implemented in the set of applications programs for the AIS. It is possible, with the addition of applications programming, to bring the AIS, or another CBI system, up to the level required for the low-cost system. The survey of existing capabilities indicated that fewer programs would have to be added to the AIS software than to other existing systems. Therefore, the AIS applications software is selected for the example system configuration.

6.0 SYSTEM ANALYSIS

Integrating the functional requirements with the hardware/software capabilities was approached by determining the system requirements dictated by the full list of functions. Then, the additional system requirements dictated by the candidate support software and programming language were assessed. Finally, the total system requirements were compared with the capabilities of the candidate hardware to determine the feasibility of utilizing that hardware with the recommended software and language to accomplish the required CAI and CMI functions.

The CAI/CMI functions and their payoff ratings were used as a starting point in determining the system requirements. An attempt was made to determine the costs, in terms of storage, I/O time, CPU time, or actual dollars, of each function. However, the functions are so heavily interrelated that, in most cases, it is not possible to assign a cost to a single function. For example, the information in a single file may service several functions. If any one of those functions is to be included, that file must be included also, but the file can then be shared by many other functions without any additional cost. In other words, costs are driven by groups of functions, and in general, a cost will be incurred if any or all of a group of functions are to be provided. Eliminating one function from among a group does not usually result in decreased system cost. Therefore, in subsequent analyses, groups of functions are the usual unit of analysis rather than single functions. However, if a single function represents a considerable impact on the system, and can be isolated, then it is treated in that way. A list of the functions, with the files required and approximate CPU times needed for each, is shown in Appendix C. These estimates derive from measured times and known file requirements in the current AIS. The detailed requirements are summed and used as a basis for sizing the system hardware.

6.1 DISK SPACE

Required disk space can be estimated from a knowledge of the files required, the required record structures, and the number of records needed. Experience on the AIS and the structures of the AIS courses were used as models in estimating storage space requirements. Parameters used were number of courses, number of students per course, and numbers of blocks and lessons per course. Information on the configuration of specific target courses was not available. Therefore, some assumptions consistent with possible application sites in Air Force resident technical training were made:

1. Five courses implemented on the system.

2. One hundred students per course per shift (500 students on CMI/CAI at any one time).

3. Five blocks of instruction per course.

4. Sixty lessons per block.

Some subparameters within these main headings were also assumed, based on current practice:

1. Two shifts of operation.

2. Students are assigned into learning centers, with 25 students in each center.

3. Three course versions (shredouts, for example) per course are implemented.

Five categories were used in estimating disk space requirements:

1. Active programs.

2. CAI.

3. CMI.

4. Recent Data File (RDF), the on-line record of the most recent student completions of the blocks and courses.

5. Support for the compiler, operating system, file management system, and the necessary support software.

The number of active programs, assuming a lower software maintenance load than on the current AIS, was estimated to be approximately 80% of current AIS usage, for a total of 30 million bytes (8 bits per byte).

Disk requirements for the CAI programs were estimated using the current AIS structure as a basis, but with a 75% safety margin. This total then is 30 million bytes.

The CMI requirements were also estimated from the AIS basis, but with a safety margin of 50% (CMI requirements can be predicted with greater accuracy). The CMI requirement is 30 million bytes.

The Recent Data File requirement depends upon how many student records the user activity will maintain on-line. An estimated 22 million bytes will be required in order to maintain, on-line, the records of the most recent 200 students to complete each of the courses and each of the blocks assumed for the low-cost system.

Support for the compiler, the operating system, the file management system, and the necessary support software will require 67 million bytes of disk storage. This includes a 50% allowance for expansion, should it be desirable to expand the system software capabilities to provide "nice to have" features in addition to the necessary features.

In summary, the total requirement for disk space for the low-cost system, assuming 200 students in the RDF, is 179 million bytes of storage.

6.2 TERMINALS

The assumptions that there will be 500 students on the system at any one time, and that 10% of the instruction will be CAI, lead to a requirement for 50 student interactive terminals. A reasonable mix for these is assumed to be 40 alphanumeric terminals, 7 low resolution graphics/color terminals, and 3 high resolution graphics terminals. Nine additional alphanumeric terminals are assumed to be required for administrative use.

The CMI functions can be accomplished with a mix of on-line and off-line management terminal devices, but the requirements will depend on specific user applications. To input off-line tests and provide printed feedback/prescription after each such input, a low-cost printer using inexpensive teletype paper is recommended, in conjunction with a forms reader, CRT, or other peripherals. Five such management terminal sites will be required to manage 500 students per shift.

In summary, the following 64 terminals would be incorporated in a "typical" configuration of the low-cost system for resident technical training:

1. Forty interactive alphanumeric terminals for student use.
2. Seven low resolution graphics/color terminals for student use.
3. Three high resolution graphics terminals for student use.
4. Nine interactive alphanumeric terminals for administrative use.
5. Five management terminal sites.

6.3 MEMORY REQUIREMENTS

Memory requirements are driven by such aspects of the system as characteristics of the operating system, number of terminals, computer architecture, and language. The CAI/CMI functions are significant factors because (a) they determine the requirements for terminals, (b) the types of presentations necessitated by the functions affect the amount of memory necessary, and (c) there will be many processes, representing the application programs which implement the functions, operating concurrently on the system. In line with the design goals and assumptions, there will be 64 users on the system at maximum load (users at 50 CAI terminals, 5 management terminal sites, and 9 administrative terminals). Therefore, there will be a maximum of 64 application processes on the system concurrently. AIS experience has shown that processes similar to those representing the application programs implementing the recommended CAI/CMI functions will run with adequate but not extravagant efficiency (i.e., producing the desired response times) when 29,000 to 30,000 bytes of central memory are allocated to each process. Therefore, the central memory requirement due to the CAI/CMI functions is 1.9 million bytes.

Support for the compiler, the operating system, the file management system, and the necessary support software requires 100,000 bytes of central memory. Much of the operating system will continuously be in central memory, but the compiler, file management, and support software will be loaded only as required.

The total central memory requirement due to the CAI/CMI functions and to software support is 2 million bytes.

6.4 DATA RATES

The recommended functions (Appendix C) were reviewed, within the framework of AIS experience, as to the signal input and output requirements for the various types of transactions, and the approximate page lengths to be displayed. Integrating the results indicates that a data rate of 1200 bits per second will be sufficient for most terminal displays. Complicated graphics displays, depending on the instructional requirements and on the terminal capabilities, could require a higher rate. Therefore, an option for higher speeds is a factor for consideration in the design of the system.

6.5 TAPE DRIVE REQUIREMENTS

The number of tape drives required is determined by two types of usage: main shift and off-shift usage. Main shift usage will consist of requests for data submitted by course personnel, requests to restore archived lessons, and requests to restore archived programs. The requests for data will include course evaluation summaries, test item evaluation reports, CAI reports, and special retrieval requests. Most of these data will be on tape. It is possible to meet this requirement with one tape drive, but a tape drive is required for each process that is running. Two drives will allow two requests to be run at the same time.

The off-shift requirements include batch jobs submitted by the on-shift personnel and periodic jobs to maintain the CAI, CMI, and program data bases. The periodic jobs will include the following:

1. Remove the CMI summary data from disk and merge with the history tapes.

2. Remove the CAI summary data from disk and merge with the history tapes.

3. Remove the test item data from disk and merge with the history tapes.

4. Archive CAI lessons that have not been used within a designated retention period.

5. Archive computer programs that have not been used within a designated retention period.

Although requirements could be met with one tape drive, there would be severe penalties. These include:

1. Only one report from tape could be run at a time.

2. A scratch area on a disk will be required to store data during merges.

3. Computer operators will have substantially more loading and unloading of tapes from drives.

4. If one drive breaks, no tape work can be done.

With two drives, two reports can be processed at the same time. The CPU is normally faster than one tape drive and can process data from one drive while reading data from the other drive. The system would also be able to go tape to memory to tape, with two tape drives. With one tape drive, the process is tape to memory to disk to memory to tape--which is substantially slower. Therefore, two tape drives are recommended for the low-cost CAI/CMI system.

6.6 HARDCOPY PRINTOUT REQUIREMENTS

The reports required for the five courses assumed to be implemented on the low-cost system can be handled easily, on an off-shift basis, by a medium speed line printer. At 600 lines per minute, production will be approximately 600 pages of printout per hour. This is more than adequate to support information retrieval and analysis requests. Therefore, a line printer capable of about 600 lines per minute is recommended.

7.0 CONFIGURATION OF AN EXAMPLE SYSTEM

The preceding sections establish the hardware, software, and functional requirements for the low-cost system, and designate candidate hardware and software items for a low-cost system. The following paragraphs configure an example system capable of meeting the requirements and design goals as previously described.

7.1 MAINFRAME AND PERIPHERALS

The example CPU, the DEC VAX 11/780, is capable of adequately but not extravagantly fulfilling the requirements for the low-cost CAI/CMI system. The example system will include mainframe and peripherals as follows:

	Cost	Monthly Maintenance
One standard VAX 11/780 package with: 1. 512K bytes of memory. 2. One REP06 176 million byte disk drive with MASSBUS adapter. 3. One TEE16 45 inch/second tape transport with MASSBUS adapter. 4. One DZ11-A asynchronous multiplexer for 8 lines. 5. One LA36 DECwriter II console.	$185,000	$827
Additional equipment to meet hardware requirements:		
1. One MS780DB 512K byte memory expansion.	22,000	110
2. One MS780DC 1,024K byte memory expansion.	35,000	220
3. One REM03-AA 67 million byte disk unit with MASSBUS adapter.	25,000	170
4. One TE16-AE 45 inch/second tape transport.	11,290	60
5. One LP11-DA 96 character 660 line/minute printer.	25,700	185
6. One DZ11-B asynchronous multiplexer for 8 lines.	1,800	21

		Cost	Monthly Maintenance
7.	Three DZ11-E asynchronous multiplexers for 16 lines at $3,850.	$ 11,550	$ 75
8.	One H9602-DF UNIBUS options cabinet.	2,300	none
	Totals	$319,640	$1,668

7.2 TERMINALS

The "typical" system configuration (section 6.1.2) includes 9 administrative terminals, 40 alphanumeric text terminals, 7 low resolution graphics/color terminals, 3 high resolution graphics terminals, and 5 management terminal sites. If the administrative terminals are the same as the student text terminals (a feature that is recommended to facilitate substitutions in case of failure), terminal requirements become (a) 49 alphanumeric terminals, (b) 7 limited graphics/color terminals, (c) 3 high resolution graphics terminals, and (d) 5 management terminal sites.

From section 4.2.5, the example alphanumeric text terminal is the ADDS Regent 100 with function key option. The example low resolution graphics/color terminal is the Intecolor 8001G with lower case and function keys. The example high resolution graphics terminal is the Tektronix 4025 with 8192 words of graphics memory. The costs for student and administrative terminals for the "typical" configuration are:

49 ADDS Regent 100 at $1100 = $53,900

7 Intecolor 8001G at $2700 = $18,900

3 Tektronix 4025 at $4495 = $13,485

$86,285

For purposes of configuring an example system, it is assumed that each of the five management terminal sites will consist of an OPSCAN 17 optical forms reader, a Teletype Model 40 ROP printer, a Digital Equipment Corporation LSI-11 mini-computer with peripheral cards, and various displays, push buttons, and specially designed circuitry. Each such terminal will cost approximately $26,000. Total cost for the five management terminal sites will be:

5 Special Management Terminals at $26,000 = $130,000.

7.3 COMMUNICATION SYSTEM

A 64-port system for 59 student and administrative terminals and five management terminal sites is required for the example system. It is assumed that four buildings (work areas) will be used in the operational low-cost system, with the computer and some classroom space in one of the buildings. To provide communications to the three remote buildings, three statistical multiplexer systems, each handling 16 terminals, will be used. The computer building is assumed to have 16 terminals connected directly to the network processing equipment of the computer.

The configuration to each of the remote buildings will include a pair of 16-channel statistical multiplexers (one at the host computer and one in the remote building connected to the terminals), a pair of short-haul modems (one at each multiplexer) operating at 9600 bits per second, and two twisted pair telephone lines. The entire communications configuration will then consist of six statistical multiplexers, six short-haul modems, and six pairs of Government furnished, twisted pair, dedicated telephone lines. Using the Digital Communications Associates (DCA) Smart/Mux 115 statistical multiplexers and the Snytech LDM-7296 short-haul modems (section 4.4.2), the cost of the example communication system is:

6 DCA Smart/Mux 115 at $4300 = $25,800
6 Syntech LDM-7296 at $ 690 = $ 4,140

$29,940

7.4 LIFE CYCLE COSTS

The initial cost of the hardware represents only part of the total cost. Some changes in the facilities, organization, and courseware will add to the initial cost. During the lifetime of the system, costs will be incurred for maintenance and support, materials and supplies, energy used, and initial, as well as some continuing, training for personnel using the system.

Eight years is used as the total life of the system. Costs for hardware and software maintenance and support are estimated and escalated for those 8 years. Some costs could not be established because of lack of required information. For example, courseware costs cannot be established unless detailed information about the target courses is known. Also, costs per work hour cannot be established without details of the internal costs of the organization furnishing the manpower. In these cases, then, a work hour estimate without dollar costs was established.

The following paragraphs indicate how the calculations were carried out, and show estimates in work hours for the identified tasks. Where appropriate, quantity discounts (over 10 units) are included. However, savings from original equipment manufacturer (OEM) agreements, which might be effected on all equipment, are not included.

7.4.1 Mainframe and Peripheral Hardware

Initial costs of the computer mainframe and peripherals (not including terminals and communication equipment) are listed below. Maintenance costs for successive years are calculated by increasing each previous year's cost by 6%, the percentage of increase projected by Digital Equipment Corporation for salary and spare parts increases.

Initial Cost (Section 7.1 above)	$319,640
Year 1 maintenance cost	20,016
Year 2 maintenance cost	21,216
Year 3 maintenance cost	22,489
Year 4 maintenance cost	23,839
Year 5 maintenance cost	25,269
Year 6 maintenance cost	26,785
Year 7 maintenance cost	28,392
Year 8 maintenance cost	30,095
Total 8 year cost	$517,741

7.4.2 Software Development

The two main areas of software development for the low-cost system are the transportability of the AIS developed software and the additional applications programs necessary to meet the functional requirements of the low-cost system. The transportability of the AIS CAMIL software is presently being carried out by the McDonnell Douglas Astronautics Company. The additional applications software is estimated to represent three work years of effort. This figure includes all functions recommended for the low-cost system (Appendix C) and not provided by current AIS applications software, except interfacing with other Air Force management systems.

7.4.3 Software Maintenance

For purposes of estimating the cost of maintaining the software of the example system, one full time application programmer and one full time system programmer are included. The maintenance will include minor improvements to the software as well as corrections to faulty software (due to programming errors in the initial software).

Should expansion of the recommended system occur at one Air Force base, the two software maintenance personnel described in the preceding paragraph could maintain four systems. Because the additional systems are duplicates of the initial system, changes or corrections made to one can easily be applied to the remaining systems.

If multiple versions of the initial system should be implemented at various bases, additional software maintenance personnel would be required. Two maintenance personnel would be necessary at the initial base, as described above, with one additional application programmer at each additional base to implement the modifications determined by the personnel at the initial base.

7.4.4 Operations

When hundreds of students and instructors enter data into a computer, "foul-ups" are inevitable. This, plus software and hardware failures, establishes a need for monitoring. AIS experience confirms the need for monitors to be located in the classrooms near the terminal areas and in the computer room.

One person with a thorough knowledge of the operation of the computer system, stationed near the terminals, can greatly improve the operation of the system and save on instructor hours. This person should be available at the terminal for correcting minor student/computer interface problems. This frees the instructor to handle the student's instructional problems. This person also is responsible for keeping the terminals in working order, and for calling maintenance with any of the more difficult operational problems. The number of persons required for this task depends on the locations of the terminals. If several management terminals are located near each other, one person can handle problems at several terminals. As physical separation grows, additional people are needed. This report assumes that the user group will furnish these personnel and that they will be trained as needed (section 7.4.10).

Computer operators are needed at central site to load tapes, answer maintenance calls, keep records, and generally monitor computer operations. Since this system is a production system, it is expected that operator intervention will be minimal. Limiting batch jobs and other tasks that require operator intervention to specified times of day further minimizes the manpower requirement. The effort per system can be minimized if the mainframes for several low-cost systems are located near each other. For cost estimation purposes, one operator per system per shift and one additional backup operator are included.

7.4.5 Terminal and Communication Equipment

The terminals and communications equipment required for a "typical" low-cost CAI/CMI system configuration are as follows (spare parts requirements are listed in section 7.4.6):

49	ADDS Regent 100	at $ 1100 =	$ 53,900
7	Intecolor 8001G	at $ 2700 =	$ 18,900
3	Tektronix 4025	at $ 4495 =	$ 13,485
6	DCA Smart/Mux 115	at $ 4300 =	$ 25,800
6	Syntech LDM-7296	at $ 690 =	$ 4,140
5	Management Terminals	at $26000 =	$130,000
	Total Purchase Price		$246,225

7.4.6 Terminal and Communication Equipment Maintenance

Because of the proliferation of equipment from different vendors, it is not practical to procure maintenance contracts from each individual vendor. Most manufacturers require that malfunctioning equipment be delivered to their own service centers. The manufacturer-service approach generally means

1. High cost per unit maintenance contracts (usually 3/4% to 1% of purchase price per month).
2. Shipping or travel time delays.
3. A requirement for many complete unit spares.

The recommended maintenance approach is to provide an on-site repair capability for non-mainframe equipment. The primary duty of these personnel is to maintain individual CRT terminals, communication equipment, and management terminal peripheral equipment (such as the forms reader, controller, and printer) by troubleshooting the equipment and replacing malfunctioning printed circuit boards or individual components. Secondary duties include accepting trouble calls from classrooms, and locating and replacing malfunctioning equipment. For cost estimation purposes, 4 work years per year are included for these tasks.

Using the on-site maintenance personnel approach, a supply of spare parts is needed for CRT terminals, communication equipment, and management terminal component equipment such as mark readers, controllers, and printers. To cover spare parts for all equipment except the printers, a spare parts budget of 7% of purchase price per year is called for. AIS experience indicates that the heavily used mechanical printers require a 25% per year budget, since the entire printer must be replaced approximately every 4 years.

Using a rate of 7% of purchase price per year for a spare parts budget for non-mainframe equipment except management terminal printers, which are figured at a 25% annual budget, the first year costs are as follows:

49	ADDS Regent 100	at $ 77	= $ 3,773
7	Intecolor 8001G	at $ 189	= $ 1,323
3	Tektronix 4025	at $ 315	= $ 945
6	DCA Smart/Mux 115	at $ 301	= $ 1,806
6	Syntech LDM-7296	at $ 48	= $ 288
5	Management Terminals--		
	Non-printer equipment	at $1540	= $ 7,700
	Printers (25% rate)	at $1000	= $ 5,000
	First Year Spare Parts Cost of Non-Mainframe Peripherals		$20,835

Using an appreciation rate of 7.5% per year for the increase in cost of replacement parts, the spare parts budget for the first 8 years would be as follows:

For year 1, the spare parts cost is $20,835
For year 2, the spare parts cost is $22,398
For year 3, the spare parts cost is $24,078
For year 4, the spare parts cost is $26,676
For year 5, the spare parts cost is $28,677
For year 6, the spare parts cost is $30,828
For year 7, the spare parts cost is $33,140
For year 8, the spare parts cost is $35,625

Total spare parts appreciated cost is $222,257

7.4.7 Facility Requirements

Installing a computerized training system in a resident technical training environment sometimes necessitates facility changes. The changes that are necessary depend, of course, on the existing physical plant, computer location, amount of mediated material, and many other factors. Without known parameters, it can only be stated here that the ideal situation is large learning centers located close to the management terminals and as close as possible to the computer room. The size of computer room needed for this installation is approximately 350 square feet. The computer room must be air conditioned to maintain approximately 70 degrees F with a 48,000 BTU per hour load.

7.4.8 Energy Requirements

The energy requirements for the system consist of the direct electrical consumption for mainframe, peripherals, and terminals, and the air conditioning for the computer room. The total direct electrical power requirement is 29 KWH per operating hour. The air conditioning requirement is for 48,000 BTU per hour.

7.4.9 Courseware Development

Introducing a CBI system into an on-going course of instruction will, almost always, entail costs for changing courseware. These changes will vary greatly depending on the existing environment. For example, an extremely important factor is whether a course is currently self-paced. Without definition of target courses, these costs have not been estimated.

7.4.10 Training

The success of any system is largely dependent upon the sophistication of its users. To this end, training costs should be included in the life cycle costs. Experience with the operation of the AIS has identified several categories of training that are highly recommended. The levels of training and the estimated hours of instruction are as follows:

1. The Deputy Commander for Training (TTC/TT) and subordinate divisions, e.g., the Plans and Requirements Division (TTCX), constitute the upper level of local training administration and management. Training at this level should consist of a system overview and will require approximately 6 instructional hours. Technical Training Group Commanders and personnel of their Resource Management Sections (TTCC) should also receive training at least equal to that provided TTC/TT.

2. Branch Chiefs and course supervisors are the next level of training management and should receive a more complete presentation of the aspects of the system. This level will require approximately 50 instructional hours.

3. Curricula and Instruction and Measurement personnel should receive training in the evaluation aspects of the system. This training will require approximately 120 instructional hours.

4. Instructor supervisors and instructors should be trained in the operational aspects of the system. The instructor supervisors should receive approximately 9 instructional hours, and the instructors should receive approximately 80 hours of instruction.

5. Course Data Base Manager and Student Control personnel should receive instruction on manipulating the course data base to fit course organization and needs. The data manager will be expected to make all data base changes and should receive 120 hours of training. The student control person will work directly in the day-to-day operations with the students and should receive 18 hours of training.

6. School Data Base Management personnel should receive more global training, becoming familiar with all courses and providing leadership and services in such areas as strategies, student management, documentation training, and course liaison. This training should be approximately 400 hours.

7.4.11 Supplies

The necessary consumable supplies, used mainly with the management terminals and off-line testing, are: (a) central site printer paper, (b) management terminal printer paper, (c) student test forms, and (d) miscellaneous supplies, such as printer ribbons, computer tapes, disk packs, tools, and cleaning supplies. Estimates of these costs are based upon current experience with AIS in usage per on-line student. The number of students on-line is assumed to be 500 per shift with two shifts. The estimated costs of these supplies are based on the following assumptions:

1. Test form usage is estimated based on the assumption of five transactions/student/shift. Total forms usage is then calculated by assuming 250 training days per year, with 30% waste and failure. Total yearly cost: $19,500.

2. Management terminal printer paper costs are estimated by using the five transactions/shift figure. The yearly cost: $6,500.

3. Central site printer paper usage is estimated by assuming that a production system will not have software development. Usage will include CMI reports, CAI authoring and evaluation, course materials development, and other administrative and evaluation usage. Usage is estimated at 30% of current AIS usage. Total yearly cost: $6,000.

4. Magnetic tapes and disk packs will be needed at the central site for data storage and backup. It is estimated that $500 per year will be required for tapes. Four extra disk packs should be purchased the first year and an average of one per year thereafter. These costs are detailed below.

   1st year = $2,700
   2nd through 8th year = $675 per year

5. Miscellaneous supplies include needs for day-to-day operations such as tools, bench stock, cleaning materials, printer ribbons, etc. The estimated yearly miscellaneous supply cost: $1,500.

The summary of supply costs, escalated at 7.5% per year, is shown below.

1st year	$36,200
2nd year	$38,915
3rd year	$41,833
4th year	$44,970
5th year	$48,342
6th year	$51,967
7th year	$55,864
8th year	$60,053

TOTAL for 8 years = $378,144.

7.4.12 Cost Summary

Paragraph/Title	Total 8 Year Cost For One System	Recurring Costs, Per Year
7.4.1 Mainframe & Peripheral Hardware	$517,741	
7.4.2 Software Development	3 MY	
7.4.3 Software Maintenance	16 MY*	2 MY*
7.4.4 Operations	16 MY*	2 MY*
7.4.5 Terminal & Communication Equipment	$246,225	
7.4.6 Terminal & Communication Maintenance	$222,257 32 MY	$27,782 4 MY
7.4.7 Facility Requirements for Computer Room	350 sq. ft.	
7.4.8 Energy Requirements, two shift operation	928 MWH 1536 MBTU	116 MWH 192 MBTU
7.4.9 Course Development	Unknown	-----
7.4.10 Training	Unknown**	-----
7.4.11 Supplies	$378,144	$47,268
SYSTEM LIFE CYCLE COSTS:		
Hardware & Supplies	$1,364,367	$75,050
Manpower	67 MY	8 MY

* Additional systems, if co-located with a first system, could share personnel.

** Required hours will depend on personnel turnover rates.

8.0 CONCLUSIONS

The principal components of a dedicated local system will include

- Computer and peripherals.
- Student and administrative terminals--alphanumerics, graphics/

color, and high resolution graphics.

- Management devices--forms reader, printer, and controller.
- Communications network.
- Software.

An operationally configured dedicated local system, to support 500 students per shift on CMI and CAI in resident technical training, can be acquired for approximately $500,000 (1979).

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APPENDIX A

LISTING OF CAI/CMI FUNCTIONS FOR SURVEY

I. STUDENT TESTING AND EVALUATION - Using the computer to assist the instructor in evaluating the student. The tests which are read and scored by the computer can include, for example, aptitude tests, lesson or block tests, performance checks, attitude measures, or biographical information. Questions could be true-false, multiple choice, or constructed response (single words, or phrases, or sentences). Students receive quick feedback, instructors don't have to score tests or record grades, and all test results are readily available for reports or evaluations.

A. Test Scoring and Feedback Capabilities - The computer system can score those tests for which test keys have been previously input. The results from each test can be printed out for the student and instructor. Questions are true-false or multiple choice.

RATING: _____

1. Answers are scored right or wrong, and a designated percent correct is required to pass the test. RATING: _____

2. Total score on the test is corrected for guessing. RATING: _____

3. Some questions can be weighted more heavily than others. RATING: _____

4. A designated percentage of a set of objectives must be passed in order to pass the test, for example 3 out of 5 objectives. RATING: _____

5. A specific objective or objectives must be passed in order to pass the test. RATING: _____

6. A specific question must be passed in order to pass the objective (or the test). RATING: _____

7. Performance checklists, as completed by the instructor, can be scored by the computer. RATING: _____

8. An instructor can bypass a test by "certifying" that the student knows the material. RATING: _____

B. Additional On-Line Testing Capabilities - Students can be tested on-line at a computer terminal. The order of questions and the sequence of alternate answers for each question can be scrambled automatically for each test administration. On retesting after an initial failure, retest can be on only the failed objectives. Questions can be true-false, multiple choice, or constructed response (English words). The amount of testing can be dependent on the student's earlier performance in the course or on this test. RATING: _____

1. Random presentation order for questions. RATING: _____

2. Random presentation order of alternative answers. RATING: _____

3. Retesting is only over failed objectives. RATING: _____

4. Questions can require constructed response (English) answers. RATING: _____

5. Amount of testing depends on performance on earlier questions in this test. RATING: _____

6. Amount of testing depends on performance earlier in the course. RATING: _____

C. Determination of Pre-Course Student Characteristics - Provides for use of student data collected before or at the beginning of training. Uses can include, for example, examining eliminations as a function of aptitude and years of school or prediction of how fast a student will complete the course. RATING: _____

1. Computer storage and retrieval of relevant Air Force personnel data - for example, ASVAB or AFQT scores, or biographical data such as previous schooling. RATING: _____

2. Storage and Retrieval of Student's Prior Knowledge of Course, Block, or Lesson Objectives - scores on criterion-referenced pretests or other measures of training objectives. RATING: _____

3. Storage and Retrieval of Student's Learning Process Skills - for example, any ability, attitude or interest type measures such as reading comprehension, study habits, etc. RATING: _____

4. Storage and Retrieval of Student's Course-Specific Critical Entry Skills - for example, aptitudes, abilities and interests that are specifically related to success in a particular training specialty, such as mathematical ability or interest in the career field. RATING: _____

D. Determination of Within-Course Student Attitudes and Interests - Provides for use of attitude or interest data collected in the course of training. Uses could include evaluation of instructional materials or procedures, prediction of completion times or rates of progress, and prediction of field performance.
RATING: _____

1. Storage and Retrieval of Student's Pre- and Post-Course Attitudes - for example, student's attitudes toward training, materials, or methods. RATING: _____

2. Storage and Retrieval of Changes in Interests or Attitudes During Training - for example, periodic questionnaires to assess interests in the training itself, or the media.
RATING: _____

II. STUDENT ASSIGNMENT (IN SELF-PACED COURSES) - Use of the computer to assign trainees to lessons, tests, or other instructional alternatives. The assignments can be based on considerations of lesson content, available resources, student characteristics, or student performance data. Students receive their next assignment immediately after completing their preceding lesson, and training resources are scheduled for optimal usage.

A. Assignment to Alternative Course Versions - Course versions which differ as to content (perhaps for different shredouts of a specialty, or to test and implement new training materials) can be established. A student enrolled in a particular course version will be assigned only the materials for that version.
RATING: _____

B. Determination of the Order of Assignments - The computer takes into account various classes of information in determining what to assign next to a trainee. The information considered can include, for example, work the trainee has completed to date, the trainee's rate of progress to date, availability of instructional resources, and requirements to assemble a team of trainees for a training task. RATING: _____

1. Order of assignments based on lessons completed to date.
RATING: _____

2. Order of assignments based on performance (time and scores) on earlier lessons. RATING: _____

3. Order of assignments based on availability of resources.
RATING: _____

4. Order of assignments based on considerations of assembling a team of trainees for a team task. RATING: _____

5. Order of assignments determined by allowing instructor to pick from available lessons. RATING: _____

C. Assignment to Alternate Lessons - Provides for student assignment to available alternate media (e.g., printed vs. audio-visual media) or alternate versions (e.g., easy versus difficult). RATING: _____

1. Based on Instructor Selection - instructors select alternates based on their assessment of the student's needs. RATING: _____

2. Based on Student Selection - students select, from lists of available alternate media or lessons, the particular one(s) they prefer. RATING: _____

3. Based on Resource Availability - computer program makes the selection of a particular media or lesson on the basis of availability. RATING: _____

4. Based on Within-Course Student Performance - computer program selects a particular media or lesson on the basis of the student's prior test scores, times-to-complete, or within-course motivation/interest. RATING: _____

5. Based on Pre-Course Student Characteristics - computer program selects a particular media or lesson on the basis of the student's general aptitudes, abilities, attitudes, interests or other pre-course data. RATING: _____

6. Computer Selections Based on Logical Rules - simple "if..then" logical rules are used in the selection of media or lessons. RATING: _____

7. Computer Selections Based on Performance Predictions - student characteristics and performance are used to predict which media or lesson is best for a given student. RATING: _____

D. Assignment to Alternative Remediation Activities - Provides for assignments to available alternate remediation materials and media (e.g., CAI reviews, instructor tutorials, etc.). RATING: _____

1. Lessons - the computer assigns each student to the best available remediation alternative for second and subsequent attempts to master lesson objectives. RATING: _____

   2. Lesson Groups - the computer assigns the best available remediation alternatives to each student who is having difficulty mastering the objectives in a related group of lessons. RATING: _____

   3. Block or Course Level - the computer assigns the best available remediation alternatives to each student who is having difficulty mastering block or course level objectives. RATING: _____

E. Test Selection and Assignment - Different forms of the tests can be selected and assigned by the computer. The computer can also determine if a particular trainee should take an on-line (CAI) or an off-line (paper and pencil) version of a test. RATING: _____

   1. Assign the different forms of a test at random. RATING: _____

   2. Exclude versions that were taken by the trainee on an earlier attempt. RATING: _____

   3. Computer determines whether to assign on-line or off-line version of test. RATING: _____

F. Assignment to Supplementary Skill Training at Course Entry - Provides for assigning those students identified as having deficiencies in critical entry or learning skill areas to supplementary or remedial skill training. Students would be assigned in these areas prior to beginning training or early in the training process by specialized materials or instructional procedures. RATING: _____

   1. Based on Critical Entry Skill Assessment - for example, students would be assigned to materials to improve their reading skills or mathematical skills prior to beginning training. RATING: _____

   2. Based on Deficient Learning Skills Assessment - for example, students would be assigned to materials to remedy deficiencies in general study habits and skills, including concentration skills, memorization skills, and test taking skills. RATING: _____

G. Additional Resource Management Considerations - The system can determine which resources are needed by a lesson, if they are available, and where they are located. Managed resources can include classroom spaces, lesson materials, media devices, work stations, simulators, and other training equipment. Students can be assigned in a manner that will even out the distribution

of students throughout the course and that will attempt to keep as many assignment options available for the student as possible.
RATING: _____

1. Student assignment to the learning center or classroom with the most room (other instructional considerations being equal). RATING: _____

2. Student assignment to blocks of instruction to achieve an optimal distribution among blocks (other instructional considerations being equal). RATING: _____

3. Capability to assign students to resources that are outside their own learning center or classroom (that is, capability to share resources among several classrooms).
RATING: _____

III. STUDENT PROGRESS MANAGEMENT - Computer-based capabilities to support the management of a trainee's progress through a self-paced training process. These capabilities range from simple scheduling to sophisticated progress prediction and management. Both the student and instructor know how the student is progressing at all times - on schedule, ahead, or behind.

A. Scheduling Student Entries into the Course - Notifying the student squadron or other authority as to which students can start the course each day based on available space in the starting block or blocks. RATING: _____

B. Graduation Forecasting - Predicting, on the basis of the student's performance in the course, the date on which he will complete the course, barring subsequent absences. Predicted graduation dates can be shown on the Learning Center roster and special reports can list the students predicted to graduate within a specified number of days. Required out-processing activities can be scheduled, reports for the Base Personnel office can be prepared, or the System can be directly interfaced to the Personnel Computer System. RATING: _____

1. Predicted graduation date shown on roster RATING: _____

2. Predicted graduation dates within a specified number of days are available by special report
RATING: _____

3. System-generated reports to Base Personnel Office
RATING: _____

4. Direct interface to Base Personnel Computer System
RATING: _____

5. System scheduling of out-processing activities
RATING: _____

C. Monitoring and Management of Student Progress to a Target - Establishing a target completion date, for the whole course or for individual blocks for each student on the basis of pre-course characteristics (e.g., ASVAB or Pre-course test scores) or performance in the early blocks of the course. Both the student and the instructor will receive feedback on the student's progress relative to his target. Targets can be made relative to either average actual course length or the POI course length.
RATING: _____

1. Targets and management printouts addressing the whole course.
RATING: _____

2. Targets and management printouts addressing individual blocks.
RATING: _____

3. Use of pre-course data in establishing target dates.
RATING: _____

4. Use of within-course data in establishing target dates.
RATING: _____

5. Targets are established relative to average course length.
RATING: _____

6. Targets are established relative to POI course length.
RATING: _____

IV. SUPPORT FOR GUIDANCE AND COUNSELING - Computer-based capabilities to support student guidance and counseling by instructors and course management personnel. These capabilities can be based on identifying entry skill deficiencies, deficiencies in within-course performance, or both. Instructors can quickly determine which students need counseling, and can retrieve from the computer the information needed to give meaningful guidance to the student.

A. Identification of Students Needing Special Attention at Course Entry - Provides for the identification and reporting of students expected to be proficient or deficient with respect to mastery of course or training objectives. This identification and reporting is initiated at the beginning of the training process to focus guidance and counseling functions on those students most in need of special training procedures.
RATING: _____

1. Students Flagged on Pre-determined Entry Variables - for example, a list of students measured as proficient or as deficient on precourse assessments can be printed.
RATING: _____

2. Proficient and Deficient Student Scores Printed - besides listing students expected to be proficient or deficient, their scores on selected critical entry skill variables (e.g., reading, math, study skills) can also be printed.
RATING: _____

3. Scores for All Students on Critical Entry Variables Printed - a report which includes the scores of all students on those variables identified as critical entry skills, flagging those student scores which are deficient. Allows extra capability to watch students who may be marginal.
RATING: _____

4. Proficient and Deficient Student Predicted Completion Times Printed - in addition to the foregoing information, the predicted training completion times can be printed for those students expected to be proficient or deficient in mastering training objectives. RATING: _____

B. Identification of Marginal Student Performance Within-Course - Provides for the identification and reporting of students expected to have difficulty mastering training objectives. Identification and reporting are initiated during training to direct special help to those students most in need of it.
RATING: _____

1. Students Flagged on Pre-determined Time and Score Variables - for example, a list of those students exceeding predetermined training time cut-offs, or scoring below predetermined criterion levels on training objectives, can be printed.
RATING: _____

2. Times and Scores for Marginal Students Printed - for example, besides listing students whose performance in training is marginal, their actual time and score data can also be printed. RATING: _____

3. Students Identified for Possible Elimination from Training - of students listed as marginal, those whose time or score data are below course-established minimums for acceptable performance would be flagged as possible candidates for elimination. RATING: _____

4. Students Identified for Specialized Remedial Training - students identified as marginal on the basis of their train-

ing times or scores receive specialized remedial training assignments (e.g., to special instructor tutorials, remediation sessions out-of-class, or special skill training for remedying learning or study skills weaknesses).
RATING: _____

V. COMPUTER-AIDED INSTRUCTION (CAI) - Lesson materials are stored in the computer, and on request are displayed to a trainee for study. The stored materials can include text, questions, and graphics. The trainee may interact with the computer through a keyboard, by pointing (touch panel), or with a light pen (pointing to or drawing on the display screen). Student interaction can range from "turning the pages" on up through very sophisticated exchanges - for example, in simulated troubleshooting, various information can be requested from the computer, and various solutions can be tested.

A. CAI Applications - There are five different ways in which CAI can be used in Air Force training: drill and practice - practice with correction and guidance of basic skills and knowledges learned via other media; tutorial - the use of CAI for particular whole lessons which are particularly difficult; simulation - use of CAI to simulate equipment or processes and to teach students to use the equipment or follow the process; review and remediation - use of CAI to quickly review the content of a block prior to a block test or to remediate over failed objectives following a block test failure; and study skills - use of CAI to teach specific study skills to students who are deficient in these areas. RATING: _____

1. Drill and Practice CAI in your training area.
RATING: _____

2. Tutorial CAI in your training area. RATING: _____

3. Simulation CAI in your training area. RATING: _____

4. CAI for Block Review prior to the block test.
RATING: _____

5. CAI for Block Remediation after a failure. RATING: _____

6. CAI for teaching study skills. RATING: _____

B. CAI Capabilities - Regardless of the particular applications, the sophistication of the CAI capability can vary from lean to rich. The most basic CAI system would present text, and allow input to multiple-choice questions via a typewriter keyboard. The CAI programs would contain the capability to adapt to the student's responses but they would not access other information about the student stored in the computer. A richer CAI system will support graphics (line drawings) as well as text, allow students to enter constructed-response (open-ended) answers, to respond by touching the screen (using a touch-sensitive surface), or with a light-sensitive pointer (light pen), control a supplementary slide or film-strip presentation, control an audio tape, and retrieve other information about the student from the data base to allow more adaptive instruction.

1. Basic CAI - presenting text, and allowing input to multiple choice questions from a keyboard. Has the capability to adapt to the answers, but does not access other information about the student. RATING: _____

2. Adding graphics capability to the basic CAI. RATING: _____

3. Adding constructed response test items (English answers) to the basic CAI. RATING: _____

4. Adding touch-sensitive or light pen capability. RATING: _____

5. Adding audio tape control to basic CAI - can present voice accompaniment during selected parts of the lesson. RATING: _____

6. Adding computer control over a slide or filmstrip projector - can present supplementary visual material to accompany the CAI display in designated parts of the lesson. RATING: _____

7. Providing additional student information from the computer data base - for example, ASVAB or AFQT scores, reading ability scores, or performance on an earlier lesson - to increase the sophistication of adapting the CAI program to the student's abilities and interests. RATING: _____

C. On-line Learning Process or Specialized Skill Training - Presentation of specialized training in a highly interactive, computer-assisted format to either students or instructors. In the case of students, the on-line materials would be designed for learning skill training (e.g., study habits and skills, test-taking skills, memorization skills) for those students identified as needing this training. In the case of instructors, the on-line materials would be designed to train diagnostic, tutorial, or other counseling skills for those instructors who volunteer or are selected for this training. RATING: _____

1. On-line Student Skill Training - for example, for students identified as deficient in critical entry skills or as having marginal within-course performance, assignment to specialized on-line materials would be provided.
RATING: _____

2. On-line Instructor Skill Training - for example, for instructors who volunteer or are selected for specialized skill/role training, assignment to specialized on-line training materials and sequences would be provided.
RATING: _____

I. CMI DATA BASE AND CAI MATERIALS PRODUCTION AND MAINTENANCE - To erform any training functions, the computer must be informed about the rainees (name, social security number, course, etc.), the course tructure (tests, lessons, resources, allowable sequences of lessons, tc.), and student performance (lessons completed, test scores, block ompletion times, etc.). The CMI Data Base refers to entry, storage, nd maintenance of this information.

In the case of Computer Assisted Instruction (CAI), all of the esson information (text, questions, graphics, branching instructions, tc.) must be stored in the computer. CAI Materials Production and aintenance refers to entry storage and maintenance of this information.

A. CMI Course Definition Data Base Editing - Used by course personnel to enter the information that describes the course structure to the computer. This editing should be easy to accomplish and easy to modify. It can be an off-line card based system (course personnel describe the course structure on paper, and later receive a printout listing what has been entered into the data base), or can run on-line (course personnel at a computer terminal enter, display, and change the information directly). To facilitate use, the on-line system can use graphics to display the course structure (the allowable paths through the lesson materials).

1. Making the system on-line, rather than the off-line card based approach. RATING: _____

2. Using graphics to display the course structure, rather than relying completely on words. RATING: _____

B. Automatic Validation of Course Data Base Integrity - Capability to check automatically if all required data base records to describe the course are present, and consistent. When a new course or course version is implemented, or an existing one is changed, all of the lessons, tests, and blocks must be in the data base. This capability will automatically check for completeness. RATING: _____

C. Editors for Production of On-Line Tests - If the System includes the capability for on-line testing, a means must be provided to enter the test questions and their alternatives into the computer system's data base - a Test Item Editor. The simplest form of the Editor would allow the author to type in text. Additional features would format the test question for the author, allow the author to decide whether or not to randomize the presentation order of test items and of alternatives within test items, control the number of attempts the student could make on each item, and enter feedback messages to follow correct and incorrect answers. RATING: _____

1. Adding automatic formatting for the entry of test questions. RATING: _____

2. Adding author control over whether order of test items and alternatives will be randomized. RATING: _____

3. Adding author control over the number of attempts allowed on a question. RATING: _____

4. Adding feedback messages for correct and incorrect answers, at the author's option. RATING: _____

D. CAI Authoring Editor - If the System includes CAI, there must be a means of producing the CAI materials or programs. The traditional approach is to have CAI authors learn an authoring language, and use it in writing their lessons. An alternative is to have CAI lessons written by an author/programmer team. These approaches require practice and experience. Another alternative is to provide a CAI Authoring Editor which structures the author's task for him, provides standardized formats for text frames and questions, and eliminates the need for any programming ability. The program format would not be rigid and alternative presentation approaches can be provided by the Editor. Instructions for using the editor can be in a manual and in addition, instructions can be displayed in the Editor program itself through a HELP request. The HELP information can refer just to the operation of the Editor or can also provide guidelines for good instructional practices.

1. Providing a CAI Authoring Editor, rather than requiring CAI authors to learn the programming language or work with a programmer to construct lessons. RATING: _____

2. Providing, in the CAI Authoring Editor, automatic formatting for text frames and for questions. RATING: _____

3. Providing, in the Editor, automatic structuring of the sequence of frames and questions in the CAI presentation. RATING: _____

4. Providing capability to copy text frames, questions, and graphics from other CAI lessons. RATING: _____

5. Providing a HELP request to display instructions for using the Editor instead of relying entirely on an instruction manual. RATING: _____

6. Adding guidelines for good instructional practices as part of a HELP request at the terminal. RATING: _____

E. Use of Test Item and CAI Authoring Editors for Off-Line Materials - If Test Item and CAI Authoring Editors are available, it may be useful to use them for producing tests and instructional materials which are intended for use off-line, e.g., regular programmed texts. The Editors can be used to write, review, and revise the tests and materials and the final product can be printed out ready to be reproduced. If the number of copies required is not too great, multiple copies can be printed to avoid the need for reproduction. Finally, small-group tryouts could be conducted on-line (like CAI) to provide more detailed information on students' reactions to the materials. RATING: _____

1. Using the Test Item Editor to construct and produce off-line tests. RATING: _____

2. Using the CAI Authoring Editor to construct and produce off-line lesson materials. RATING: _____

3. Using Editors for review and revision of tests and lesson materials. RATING: _____

4. Printing out a master copy, ready for reproduction, of tests and materials which have been written using the Editors. RATING: _____

5. Printing out multiple copies of tests and materials, in order to bypass reproduction for small quantities. RATING: _____

6. Providing capability for conducting on-line small group tryouts of materials and tests. RATING: _____

F. Use of On-Line Editors for Production and Maintenance of Course Documents - An Editor like those described for Test Items and CAI authoring could be used for producing course documents such

as the POI, course charts, lesson outlines, etc. The documents would then be available at any time through the Editors for review or revision and copies could be printed out as needed.
RATING: _____

VII. INFORMATION RETRIEVAL AND REPORTS - In a computer-based training system, large amounts of information about trainees, courses, course materials, tests and test items, and other parts of the system are stored, and are available for periodic (hourly, daily, weekly, monthly....) analyses and reports. These functions are intended principally for instructors, managers, and administrators. They can be valuable to instructors who must provide management and guidance to students. They also can be valuable in providing quality control over students and materials, in improving the management and administration of training, and in evaluating and improving all aspects of development and implementation of training materials and programs.

A. Reports for Instructors - Large amounts of data can be collected and made available to instructors, but the reports should be carefully structured to meet the needs of the instructors. The reports may include: classroom rosters, summaries for specific parts of the course, individual history reports, and summaries for the classroom. RATING: _____

1. Learning Center or Classroom Rosters - Rosters can be displayed or printed to show many different kinds of information about each of the students in a classroom or learning center. The basic information would include social security numbers, names, carrel (or position) numbers, absences, current block, and rate of progress. RATING: _____

2. Individual Block Progress Reports - The computer system can allow review of data by instructors, supervisors, counselors, etc., via local terminals. Progress reports can provide data for in-course counseling and can become economical replacements for some of the current manually prepared forms which accompany student records throughout the course and, in some cases, beyond graduation. An Individual Block Progress Report will summarize student progress, times and scores, and other pertinent information.
RATING: _____

Information included in the block progress reports can include some or all of the following:

a) lessons completed by the student; RATING: _____

b) numbers of attempts, and scores on each attempt, on each lesson; RATING: _____

c) objectives failed during the block; RATING: _____

d) time spent on each lesson and on the block; RATING: _____

e) amount of time student is ahead or behind schedule; RATING: _____

f) amount of homework student has accomplished. RATING: _____

3. Individual Student History Reports - The system can provide a large amount of additional data about an individual student. This can include the student's scores on precourse aptitude and interest measures, scores on critical entry skill tests, time spent in block remediation following a block failure, and absence times and reasons for absence. RATING: _____

Information in the Individual Student History Report can include some or all of the following:

a) attitude and interest information; RATING: _____

b) scores on critical entry skills; RATING: _____

c) time in block remediation following a block failure; RATING: _____

d) lesson objectives that were failed more than twice; RATING: _____

e) time absent in each block, and reasons for absences. RATING: _____

4. Additional Reports on the Student -

a) Absence Report, to replace the manual absence report; RATING: _____

b) Homework Summary Report, to list lessons accomplished as homework and to summarize homework time expended; RATING: _____

c) On-line display of student data - the capability to call up and display any of the available student information. RATING: _____

B. Training Management Reports - Reports such as these are intended for use by managers (Shift Supervisors and above) in monitoring training activities. Potential reports include number of students awaiting training and how long they have been waiting, number of trainees in each block or each classroom on each base, the distribution of completion times for blocks and the course itself, differences in trainee performance between parallel classrooms or bases, the extent to which instructional resources such as carrels, equipment, and training devices are being utilized, and summaries, by block or other unit, of trainee performance.

1. Report on Students Awaiting Training; RATING: _____
2. Report of number of students currently in each block, classroom, or on each base; RATING: _____
3. The distribution of completion times for individual blocks; RATING: _____
4. The distribution of course completion times; RATING: _____
5. Differences in student performance across parallel learning centers, classrooms or bases; RATING: _____
6. Reports of instructional resource (facilities, training devices, etc.) utilization; RATING: _____
7. Report of utilization and performance of instructors. RATING: _____
8. Summary Reports of student completion times and final grades, by block. RATING: _____

C. Course Evaluation Summary - Summarizes student performance on individual lessons within blocks and on the block itself. It is intended for use in small-group tryouts of new materials and monitoring student performance on established materials. The Course Evaluation Summary can contain a variety of features, listed below. RATING: _____

1. First-attempt lesson and block test scores. RATING: _____
2. Final lesson and block test scores. RATING: _____
3. Mean and standard deviation of first-attempt lesson and block test scores. RATING: _____

4. Mean and standard deviation of final lesson and block test scores. RATING: _____

5. Mean and standard deviation of first-attempt lesson and block times. RATING: _____

6. Mean and standard deviation of lesson and block completion times. RATING: _____

7. Separate score and time data for alternative modules within lessons. RATING: _____

8. Score data broken out by objective within lessons. RATING: _____

9. First-attempt lesson failure rates. RATING: _____

10. First-attempt objective failure rates. RATING: _____

11. Correlations showing the relationship between predicted and actual lesson and block times and scores. RATING: _____

12. Summarized data on lessons, modules and objectives with first-attempt failure rates above a certain percentage. RATING: _____

D. Test Item Evaluation Report - Provides detailed information on the characteristics of block and lesson tests. It could contain a variety of features, listed below. RATING: _____

1. The number (or percentage) of trainees selecting each alternative answer to test questions. RATING: _____

2. Percentage of trainees answering each question correctly. RATING: _____

3. Average test score of trainees selecting each alternative on each question. RATING: _____

4. Flagging test questions missed by over 70 percent or by none of the trainees. RATING: _____

5. Item-remainder correlations for each question. RATING: _____

6. Means and standard deviations of scores for each objective and for each full test. RATING: _____

7. Distribution of scores on the full test. RATING: _____

8. Alpha reliability coefficient for each objective and for the full test. RATING: _____

9. Criterion-referenced reliability coefficients for each objective and for the full test. RATING: _____

E. CAI Evaluation Data - Since CAI involves frequent interaction with the student, very detailed evaluation data are available from CAI programs. The most frequent use of this information would be during formative evaluation (small-group tryouts) of the programs. A variety of capabilities are listed below.

1. Percentage of students selecting each alternative in each question frame. RATING: _____

2. Percentage of students selecting each alternative in each question frame on their first try, their second try, etc. RATING: _____

3. The means and standard deviations of the time to respond to question frames and the time to read text frames. RATING: _____

4. Lists of unanticipated responses to constructed response questions. RATING: _____

5. Lists of open-ended student comments about the CAI program. RATING: _____

6. Detailed records of each student's path through a CAI program. RATING: _____

7. Summary statistics on major units of the program, such as time to complete and cumulative score.
RATING: _____

F. Courseware Development Management Reports - When Editors are used for developing on-line tests, CAI materials, or tests and materials to be used off-line, the System can capture information about authors' work on the Editors and the status of the development effort. This information could then be summarized in management reports for monitoring materials production, review, revision, and implementation. The reports could include information such as the person responsible for developing, reviewing, or revising a lesson, how long they have been working on it, how much of the work has been completed, and expected completion date. RATING: _____

G. Performance Forecast Reports - Provides field, OJT, or technical training personnel with training information which describes current student performance levels or predicts how individual students will perform in specific training areas.
RATING: _____

1. Pre-Service Education and/or Vocational Training - available individual data relevant to prior education or training.
RATING: _____

2. Pre-Service Occupational/Job Experience - data which reflects prior relevant job experience.
RATING: _____

3. Enlistment/Classification Data - data available in AF personnel records (e.g., ASVAB scores, AFOQT or AFQT scores).
RATING: _____

4. In-Service Training Performance Data - for example, for FTD or OJT managers, a report of individual student technical training or in-service training performance data (e.g., scores, times-to-complete).
RATING: _____

5. AF Specialty-Related Deficiencies - for example, student data on deficiencies in skills, experiences, or abilities relevant to that particular individual's specialty.
RATING: _____

6. Students' Predicted Adaptability, Performance and Progression in Operational Field Assignments - for example, students' in-service and pre-service data could be used to provide reports of predicted field assignment adaptability, performance and progression.
RATING: _____

H. Special Purpose Reports - No matter how extensive, no set of standard reports will always be enough to answer all management and evaluation questions. It is useful, therefore, to have an open-ended information retrieval capability that can be used to answer unexpected questions about student and System performance. A minimal capability would permit the user to define the variables which he wishes to look at, and the types of students and time periods from which the data are to be drawn. The output would consist of the number of cases found, and the mean, standard deviation, and range for each included variable. Such a program could be run interactively, in a minute or so, and the results displayed on the user's screen or it could be run as a background job, in a half-hour or so, and the results printed out.

1. Utility of basic Data Retrieval Program with only background capability. RATING: _____

2. Utility of adding interactive (as well as background) capability. RATING: _____

3. The basic data retrieval program could also be interfaced to one of the standard packages of statistical programs (for example, SPSS, or BMD). This would permit extensive analysis of student data and the capability to answer just about any question that could be asked about the data collected in the system. Some training is, however, required to use these statistical packages. RATING: _____

APPENDIX B

INTRODUCTION TO SURVEY FORM AND EXPLANATION OF RATING SCALE

OPERATIONAL COMPUTER-BASED TRAINING SYSTEM REQUIREMENTS

A highly sophisticated, prototype computer-based training system has been developed and implemented at Lowry AFB. This Advanced Instructional System, or AIS, represents the state-of-the-art in both instructional and computer technology, and has contributed to training time savings of 30% or more in a variety of technical training areas. As a prototype system, however, the AIS provides functions and capabilities that may not be necessary in the operational training environment. To realize the full potential of computer-based systems for Air Force training, we want to find out what functions or capabilities will have the highest payoff for operational training.

You have been selected to participate in this survey to determine what functions are most valuable in your training area. Your assistance in carefully analyzing the value of various computer-based functions is extremely important. Your ratings, along with the ratings of the other participants, will be used in defining a low-cost computer-managed and computer-assisted instruction (CMI/CAI) system for Air Force training.

The following pages describe the many functions that a computer could perform in a training system. Please read the description of a function, and then carefully consider what that function could accomplish in your particular area of training. The question you are to answer, for each function, is:

"HOW MUCH IS THIS FUNCTION WORTH TO MY AREA OF AIR FORCE TRAINING?" Payoff potential can come from any of the following:

- Reduced training time, students get through faster;
- Reduced administrative load on instructors;
- Better use of training resources;
- Improved quality control over students or materials;
- Improved management/administration of training; and
- Improved materials development process, resulting in better instructional materials and reduced development time.

On the following pages, there are eight brief general descriptions of various areas in which the computer could provide training support.

Under each of the general area descriptions, specific areas of computer-based training functions are described. You are asked to consider how much each of these might be worth to Air Force training in your particular area, and to assign a rating of:

1 = Very high payoff potential;

2 = High payoff potential;

3 = Moderate payoff potential;

4 = Small payoff potential;

5 = No payoff potential; and

X = No opinion - this function's effects would be outside my area, and I cannot estimate its payoff potential.

If there are functions or features that should be included in a computer-based training system for your area of Air Force training, and that are not listed, please describe these on the last page of this packet.

If you are involved in resident training, then assume that your area of training would be self-paced before the computer-based training system is introduced. This is important, because many of the computer functions could be quite valuable in self-paced training but of little value in conventional lockstep instruction. Remember, as you assign ratings, that you are to consider the payoff of each function in self-paced training.

If you have any questions, please ask the representative conducting this survey.

APPENDIX C

LISTING OF CAI/CMI FUNCTIONS, IN THE ORDER USED ON THE SURVEY FORMS, WITH MEAN RATINGS FROM RESIDENT TECHNICAL TRAINING, AND ESTIMATED SYSTEM IMPACTS (FILE REQUIREMENTS AND CPU TIMES). THE FUNCTIONS WHICH ARE RECOMMENDED FOR OMISSION FROM THE LOW-COST SYSTEM ARE INDICATED IN THE FAR LEFT COLUMN.

Items are designated as (I), (S), or blank. The (I) items appeared only on the instructor survey form, (S) items only on the supervisor form, and the blank items appeared on both instructor and supervisor forms.

			FUNCTION	/ VALUE	FILES NEEDED	CPU TIME
	#######		I - STUDENT TESTING AND EVALUATION #######			
		IA	TEST SCORING AND FEEDBACK	/ 2.17	K,R,S	100 MSEC/ TRANSACTION
	(I)	IA1	RIGHT-WRONG WITH PERCENT CORRECT	/ 2.20	K,S	
DROP	(I)	IA2	CORRECT SCORE FOR GUESSING	/ 3.20	K,S	
DROP	(I)	IA3	WEIGHT QUESTIONS DIFFERENTIALLY	/ 2.60	K,S	
	(I)	IA4	PASS CERTAIN PERCENT OF OBJECTIVES	/ 2.46	K,S	
	(I)	IA5	PASS SPECIFIC OBJECTIVES	/ 2.25	K,S	
DROP	(I)	IA6	PASS SPECIFIC QUESTIONS	/ 3.30	K,S	
	(I)	IA7	SCORE PERFORMANCE CHECKLISTS	/ 3.06	K,S	
	(I)	IA8	INSTRUCTOR CAN CERTIFY LESSON PASS	/ 3.34	K,S	
			(NOTE: IA7 AND IA8, RATED LOW BUT NEEDED)			
	(S)	IB	ADDITIONAL ON-LINE TEST CAPABILITIES	/ 2.26	I,K,S,T	5 MSEC/SEC/ STUDENT
	(I)	IB1	ON-LINE, RANDOM QUESTION ORDERS	/ 2.30	I,K,S,T	
	(I)	IB2	ON-LINE, RANDOM ORDERS OF ALTERNATIVES	/ 2.31	I,K,S,T	
	(I)	IB3	ON-LINE, RETEST OVER FAILED OBJECTIVES	/ 2.94	I,K,S,T	
DROP	(I)	IB4	ON-LINE, CONSTRUCTED RESPONSES	/ 2.70	CT	
	(I)	IB5	ON-LINE, ADAPTIVE WITHIN TEST	/ 2.85	CB,CO,CT	
DROP	(I)	IB6	ON-LINE, ADAPTIVE ON COURSE PERFORMANCE	/ 2.91	CB,CO,CT	

APPENDIX C (CONTINUED)

		FUNCTION	/ VALUE	FILES NEEDED	CPU TIME
	IC	PREASSESSMENT DATA CAN BE USED	/ 2.57		
(I)	IC1	RELEVANT AF PERSONNEL DATA CAN BE USED	/ 2.53	S	BATCH
(I)	IC2	PRE-COURSE KNOWLEDGE TESTS	/ 2.39	K,S	
(I)	IC3	LEARNING PROCESS SKILLS	/ 2.29	K,S	
(I)	IC4	COURSE-SPECIFIC ENTRY SKILLS	/ 2.40	K,S,V	
	ID	ATTITUDES AND INTERESTS	/ 2.66	K,S	
(I)	ID1	PRE AND POST ATTITUDES	/ 2.78	K,S	
(I)	ID2	WITHIN COURSE ATTITUDES AND INTERESTS	/ 2.82	K,S	
####### II - STUDENT ASSIGNMENT #######					
	IIA	ASSIGN TO ALTERNATE COURSE VERSIONS	/ 2.80	H,S	
	IIB	DETERMINE ORDER OF ASSIGNMENTS	/ 2.56	H	
(I)	IIB1	ORDER BASED ON LESSONS COMPLETED	/ 2.56	H,S	
(I)	IIB2	ORDER BASED ON EARLIER PERFORMANCE	/ 2.55	H,S	4 MSEC/ TRANSACTION
(I)	IIB3	ORDER BASED ON RESOURCE AVAILABILITY	/ 2.50	F,R	4 MSEC/ TRANSACTION
(I)	IIB4	ORDER BASED ON TEAM CONSIDERATIONS	/ 2.74	H,L,S	1 MSEC/ TRANSACTION
DROP (I)	IIB5	ORDER SELECTED BY INSTRUCTORS	/ 2.93	D,L,M, N,S	3 MSEC/ TRANSACTION
	IIC	ASSIGN TO ALTERNATE LESSON TREATMENTS	/ 2.70		
DROP (I)	IIC1	INSTRUCTOR ASSIGNS ALTERNATES	/ 2.79	L,M,N,S	
DROP (I)	IIC2	STUDENT SELECTS DESIRED ALTERNATES	/ 3.71	D,L,M,N,S	
(I)	IIC3	RESOURCES DICTATE ALTERNATE ASSIGNMENT	/ 2.89	F	3 MSEC/ TRANSACTION

APPENDIX C (CONTINUED)

		FUNCTION	/ VALUE	FILES NEEDED	CPU TIME
(I)	IIC4	IN-COURSE PERFORMANCE DETERMINES ASSIGNMENT	/ 2.75	H,L,S	3 MSEC/ TRANSACTION
(I)	IIC5	PRE-COURSE MEASURES DETERMINE ASSIGNMENT	/ 2.84	H,L,S	
(I)	IIC6	HEURISTIC RULES FOR ASSIGNMENT SELECTION (NOTE: IIC6 IS LOW VALUE, BUT USEFUL)	/ 3.38	H,L,S	
(I)	IIC7	PERFORMANCE PREDICTION DETERMINES ASSIGNMENT	/ 2.95	H,L,S	
(S)	IID	ASSIGN TO ALTERNATE REMEDIATIONS	/ 2.61		
(I)	IID1	ASSIGN TO ALTERNATE LESSON REMEDIATION	/ 2.38	L,N	10 MSEC/ TRANSACTION
(I)	IID2	ASSIGN TO ALTERNATE LESSON GROUPS REMEDIATION	/ 2.45	D,L,M, N,S	10 MSEC/ TRANSACTION
(I)	IID3	ASSIGN TO BLOCK OR COURSE REMEDIATIONS	/ 2.53	D,L,M, N,S	10 MSEC/ TRANSACTION
	IIE	TESTS SELECTED AND ASSIGNED	/ 2.86	H,L,S	
(I)	IIE1	TEST ASSIGNMENT AT RANDOM	/ 2.86	H,L,S	
(I)	IIE2	TEST ASSIGNMENT EXCLUDES PREVIOUSLY TAKEN TESTS	/ 2.52	H,L,S	
(I)	IIE3	ASSIGNMENT TO ON-LINE OR OFF-LINE TESTS	/ 2.98	H,L,S	
	IIF	ASSIGNMENT TO SUPPLEMENTARY SKILL TRAINING ON ENTRY	/ 2.28	H,K,S	
(I)	IIF1	ASSIGN SUPPLEMENTARY TRAINING BASED ON ENTRY SKILLS	/ 2.10	H,K,S	
(I)	IIF2	ASSIGN SUPPLEMENTARY TRAINING BASED ON LEARNING SKILLS	/ 2.16	H,K,S	
(I)	IIG	RESOURCE MANAGEMENT BY COMPUTER	/ 2.48	F,P,S	
(I)	IIG1	RESOURCES: ASSIGN TO LEARNING CENTERS	/ 2.74	P,S	1 MSEC
(I)	IIG2	RESOURCES: ASSIGN TO OPTIMIZE ACROSS BLOCKS	/ 2.98	H,P,S	1 MSEC
(I)	IIG3	RESOURCES: MANAGE OUTSIDE LEARNING CENTER	/ 2.88	F,S	3 MSEC

APPENDIX C (CONTINUED)

		FUNCTION	/ VALUE	FILES NEEDED	CPU TIME
		####### III - STUDENT PROGRESS MANAGEMENT #######			
		IIIA SCHEDULE STUDENT ENTRIES TO COURSE	/ 2.39	P,S	
		IIIB GRADUATION FORECASTING	/ 2.47		
	(I)	IIIB1 PREDICTED GRADUATION DATES ON ROSTER	/ 2.74	C,P,S,W	3 MSEC/SEC/ OCCURRENCE
	(I)	IIIB2 GRADUATES IN NEXT X DAYS, LISTED ON REPORT	/ 2.64	C,P,S,W	3 MSEC/SEC/ OCCURRENCE
		IIIB3 GRADUATION REPORTS FOR CBPO	/ 2.62	C,P,S,W	BATCH
		IIIB4 DIRECT INTERFACE TO PERSONNEL SYSTEM	/ 2.51	(NEEDS DEFINITION FROM AIR FORCE)	
DROP		IIIB5 GRADUATES: SCHEDULE OUT-PROCESSING	/ 2.58	E,S	BATCH
		IIIC MANAGE STUDENT TO TARGET	/ 2.83	H	
	(I)	IIIC1 MANAGEMENT TARGETS PRINTED FOR WHOLE COURSE	/ 2.83	C,H,P,S	
	(I)	IIIC2 MANAGEMENT TARGETS PRINTED FOR INDIVIDUAL BLOCKS	/ 2.89	C,H,P,S	
	(I)	IIIC3 MANAGEMENT TARGETS BASED ON PRE-COURSE DATA	/ 3.02	C,H,S,W	
	(I)	IIIC4 MANAGEMENT TARGETS, FROM WITHIN-COURSE DATA	/ 2.69	C,H,S,W	
	(I)	IIIC5 MANAGEMENT TARGETS RELATIVE TO AVERAGE COURSE LENGTH	/ 2.92	C,H,S,W	
DROP	(I)	IIIC6 MANAGEMENT TARGETS, RELATIVE TO POI LENGTHS	/ 2.97	C,H,S,W	

APPENDIX C (CONTINUED)

		FUNCTION	/ VALUE	FILES NEEDED	CPU TIME
		####### IV - SUPPORT FOR GUIDANCE AND COUNSELING #######			
	IVA	IDENTIFY STUDENTS NEEDING SPECIAL ATTENTION	/ 2.30	C,E,P, S,V	5 MSEC/STUDENT CONSIDERED
(I)	IVA1	FLAGGED ON ENTRY VARIABLES	/ 2.45	C,E,P, S,V	
(I)	IVA2	PROFICIENCY AND DEFICIENCY SCORES PRINTED	/ 2.38	C,E,P, S,V	
(I)	IVA3	SCORES ON CRITICAL ENTRY VARIABLES PRINTED	/ 2.39	C,E,P, S,V	
(I)	IVA4	PREDICTED COMPLETION TIMES, PROFICIENCY/DEFICIENCY	/ 2.64	C,E,P, S	
	IVB	IDENTIFY MARGINAL PERFORMANCE IN COURSE	/ 2.32	C,E,P, S,W	
(I)	IVB1	FLAGGED ON TIME AND SCORE VARIABLES	/ 2.55	C,E,P, S,W	
(I)	IVB2	MARGINAL TIMES AND SCORES PRINTED OUT	/ 2.50	C,E,P, S,W	
(I)	IVB3	FLAGGED FOR ELIMINATION FROM TRAINING	/ 2.26	C,E,P, S,W	
(I)	IVB4	FLAGGED FOR SPECIAL REMEDIAL TRAINING	/ 2.30	C,E,P, S,W	

APPENDIX C (CONTINUED)

		FUNCTION	/ VALUE	FILES NEEDED	CPU TIME
####### V - COMPUTER-AIDED INSTRUCTION (CAI) #######					5 MSEC/SEC/ STUDENT
	VA	CAI APPLICATIONS, TRAINING AND TESTING	/ 2.36	P,Q,S, ALL CAI FILES	
(I)	VA1	CAI DRILL AND PRACTICE	/ 2.80	P,Q,S, ALL CAI FILES	
(I)	VA2	CAI TUTORIAL	/ 2.81	P,Q,S, ALL CAI FILES	
(I)	VA3	CAI SIMULATION (LIMITED CAPABILITY)	/ 2.87	P,Q,S, ALL CAI FILES	
(I)	VA4	CAI FOR BLOCK REVIEW	/ 2.67	H,K,M,P, Q,S,X,ALL CAI FILES	
(I)	VA5	CAI FOR BLOCK REMEDIATION	/ 2.47	P,Q,S, ALL CAI FILES	
(I)	VA6	CAI FOR TEACHING STUDY SKILLS	/ 2.67	P,Q,S, ALL CAI FILES	

APPENDIX C (CONTINUED)

	FUNCTION		/ VALUE	FILES NEEDED	CPU TIME
	VB	CAI CAPABILITIES	/		5 MSEC/SEC/ STUDENT ON CAI
	VB1	BASIC CAI CAPABILITIES	/ 3.16	ALL CAI FILES	
	VB2	BASIC CAI PLUS GRAPHIC CAPABILITIES	/ 2.74	CT	
	VB3	BASIC CAI PLUS CONSTRUCTED RESPONSE CAPABILITY	/ 2.85	CT	
	VB4	BASIC CAI PLUS TOUCH PANEL OR LIGHT PEN	/ 2.92		
	VB5	BASIC CAI PLUS CONTROL OF AUDIO TAPE PLAYER	/ 2.69		
	VB6	BASIC CAI PLUS CONTROL OF SLIDE OR FILM PROJECTOR	/ 2.74		
	VB7	BASIC CAI PLUS INTERFACE WITH THE CMI DATA BASE	/ 2.70	S	
	VC	CAI FOR TRAINING ON LEARNING PROCESSES AND SPECIAL SKILLS	/ 2.62		
(I)	VC1	CAI FOR STUDENT SKILL TRAINING	/ 2.44		
(I)	VC2	CAI FOR INSTRUCTOR SKILL TRAINING	/ 2.49		

APPENDIX C (CONTINUED)

		FUNCTION	/ VALUE	FILES NEEDED	CPU TIME
	#######	VI - CMI DATA BASE AND CAI MATERIALS PRODUCTION AND MAINTENANCE		#######	
	VIA	CMI COURSE DEFINITION DATA BASE EDITING	/		
	VIA1	ON-LINE CMI DATA BASE EDITING	/ 2.76	ALL FILES IN CMI DATA BASE	
	VIA2	GRAPHICS FOR COURSE STRUCTURE DISPLAY	/ 2.65	H	
	VIB	AUTOMATIC VALIDATION OF COURSE DATA BASE	/ 2.27	C,F,H,K, L,M,P,R, X,W	
(S)	VIC	EDITORS FOR PRODUCING ON-LINE TESTS	/ 2.32	I,K	15 MSEC/SEC/ AUTHOR
(I)	VIC1	AUTOMATIC FORMAT FOR ENTRY OF TEST QUESTIONS	/ 2.50	I,K	
(I)	VIC2	RANDOMIZED QUESTIONS AND ALTERNATIVES	/ 2.50	I,K	
(I)	VIC3	CONTROL NUMBER OF ATTEMPTS PER QUESTIONS	/ 2.55	ALL CAI FILES	
(I)	VIC4	FEEDBACK FOR RIGHT/WRONG, IF DESIRED	/ 2.26	ALL CAI FILES	
	VID	CAI AUTHORING EDITOR	/		20 MS/S/AUTHOR
	VID1	PROVIDE AUTHORING EDITOR, NOT TEAM WRITING	/ 2.50	ALL CAI FILES	
	VID2	AUTHORING EDITOR FORMATS TEXT FRAMES AND QUESTIONS	/ 2.48	ALL CAI FILES	
	VID3	AUTHORING EDITOR STRUCTURES SEQUENCE OF FRAMES	/ 2.49	ALL CAI FILES	
	VID4	AUTHORING EDITOR COPIES FRAMES FROM OTHER LESSONS	/ 2.53	ALL CAI FILES	
	VID5	AUTHORING EDITOR HAS USER "HELP" INSTRUCTIONS	/ 2.38	ALL CAI FILES	
	VID6	AUTHORING EDITOR HAS "HELPS" FOR WRITING PRACTICES	/ 2.47	ALL CAI FILES	
	VIE	USE AUTHORING EDITOR FOR OFF-LINE MATERIALS	/ 2.50	CL,CO, CT	20 MS/S/AUTHOR
	VIE1	USE AUTHORING EDITOR FOR OFF-LINE TESTS	/ 2.58	CL,CO, CT	
	VIE2	USE AUTHORING EDITOR FOR OFF-LINE LESSONS	/ 2.60	CL,CO, CT	

APPENDIX C (CONTINUED)

FUNCTION		/ VALUE	FILES NEEDED	CPU TIME
VIE3	AUTHORING EDITOR TO REVIEW/REVISE OFF-LINE MATERIALS	/ 2.51	CL,CO, CT	
VIE4	PRINT MASTER COPY FOR OFF-LINE MATERIALS	/ 2.35	CL,CO, CT	
VIE5	PRINT MULTIPLE COPIES FOR TRYOUTS	/ 2.37	CL,CO, CT	
VIE6	CONDUCT ON-LINE TRYOUTS	/ 2.28	ALL CAI FILES	
VIF	USE EDITORS FOR COURSE DOCUMENTATION	/ 2.18	CL,CO, CT	15 MSEC/SEC/ ON-LINE USER
####### VII - INFORMATION AND REPORTS #######				
VIIA	REPORTS FOR INSTRUCTORS	/ 2.32	M,P,S	
VIIA1	LEARNING CENTER ROSTERS	/ 2.41	M,P,S	
VIIA2	BLOCK PROGRESS REPORTS	/ 2.25	M,S	
VIIA2A	LESSONS STUDENT HAS COMPLETED	/ 2.37	M,S	
VIIA2B	ATTEMPTS AND SCORES ON LESSONS	/ 2.37	M,S	
VIIA2C	OBJECTIVES FAILED IN BLOCK	/ 2.16	M,S	
VIIA2D	TIME ON LESSONS AND ON BLOCK	/ 2.31	M,S	
VIIA2E	TIME AHEAD OR BEHIND SCHEDULE	/ 2.49	M,S	
VIIA2F	HOMEWORK ACCOMPLISHED	/ 2.66	M,P,S	

APPENDIX C (CONTINUED)

	FUNCTION	/ VALUE	FILES NEEDED	CPU TIME
	VIIA3 STUDENT HISTORY REPORTS	/ 2.42	M,P,S	
	VIIA3A ATTITUDE AND INTEREST INFORMATION	/ 2.82	M,P,S	
	VIIA3B SCORES ON ENTRY SKILLS	/ 2.47	M,P,S	
	VIIA3C TIMES IN BLOCK REMEDIATION	/ 2.59	M,P,S	
	VIIA3D OBJECTIVES FAILED MORE THAN TWICE	/ 2.34	M,P,S	
	VIIA3E ABSENCE TIMES AND REASONS, BY BLOCKS	/ 2.62	M,P,S	
	VIIA4A ADDITIONAL REPORT: ABSENCE REPORT	/ 2.58	A,P,S	
	VIIA4B ADDITIONAL REPORT: HOMEWORK SUMMARY	/ 2.79	M,P,S	
	VIIA4C ADDITIONAL REPORT: ON-LINE DISPLAY OF STUDENT DATA	/ 2.31	M,S	
	VIIB TRAINING MANAGEMENT REPORTS	/		
(S)	VIIB1 REPORT, STUDENTS AWAITING TRAINING	/ 2.76	E,S	
(S)	VIIB2 REPORT, STUDENTS BY BLOCK, ROOM, OR BASE	/ 2.63	E,P,S	
(S)	VIIB3 REPORT, DISTRIBUTION OF BLOCK TIMES	/ 2.70	RDF,V	
(S)	VIIB4 REPORT, DISTRIBUTION OF COURSE TIMES	/ 2.71	RDF,V	
(S)	VIIB5 REPORT, PERFORMANCE BY ROOMS OR BASES	/ 2.95	E,P,S	
(S)	VIIB6 REPORT, RESOURCE UTILIZATION	/ 2.64	F,P	
(S)	VIIB7 REPORT, INSTRUCTOR UTILIZATION/PERFORMANCE	/ 2.54	F,P	
(S)	VIIB8 REPORT, STUDENT TIMES AND GRADES BY BLOCKS	/ 2.60	RDF,V	

APPENDIX C (CONTINUED)

	FUNCTION		/ VALUE	FILES NEEDED	CPU TIME
(S)	VIIC	COURSE EVALUATION SUMMARY	/ 2.52	Z	
(S)	VIIC1	FIRST ATTEMPT TIMES AND SCORES	/ 2.62	Z	
(S)	VIIC2	FINAL TIMES AND SCORES	/ 2.53	Z	
(S)	VIIC3	MEAN, SD, FIRST ATTEMPT TIMES AND SCORES	/ 2.96	Z	
(S)	VIIC4	MEAN, SD, FINAL LESSON AND BLOCK SCORES	/ 2.93	Z	
(S)	VIIC5	MEAN, SD, FIRST ATTEMPT LESSON AND BLOCK TIMES	/ 2.94	Z	
(S)	VIIC6	MEAN, SD, LESSON AND BLOCK COMPLETION TIMES	/ 2.89	Z	
(S)	VIIC7	SCORE AND TIME DATA BY LESSON ALTERNATES	/ 2.88	Z	
(S)	VIIC8	SCORE DATA BY OBJECTIVES IN LESSONS	/ 2.68	Z	
(S)	VIIC9	FIRST ATTEMPT LESSON FAIL RATES	/ 2.70	Z	
(S)	VIIC10	FIRST ATTEMPT OBJECTIVE FAIL RATES	/ 2.67	Z	
(S)	VIIC11	CORRELATIONS OF ACTUAL WITH PREDICTED TIME AND SCORE	/ 2.80	Z	
(S)	VIIC12	SUMMARY, FAIL RATES ABOVE "X" PERCENT	/ 2.72	Z	
(S)	VIID	TEST ITEM EVALUATION REPORT	/ 2.23	Z	
(S)	VIID1	TIMES EACH ALTERNATIVE IS SELECTED	/ 2.27	Z	
(S)	VIID2	TIMES EACH QUESTION IS ANSWERED CORRECTLY	/ 2.20	Z	
(S)	VIID3	FOR ALTERNATIVES, AVERAGE TEST SCORE	/ 2.44	Z	
(S)	VIID4	FLAG ALTERNATIVES MISSED BY X% OR MORE	/ 2.07	Z	
(S)	VIID5	ITEM REMAINDER CORRELATIONS	/ 2.50	Z	
(S)	VIID6	MEAN AND SD OF SCORES BY OBJECTIVE AND TEST	/ 2.57	Z	
(S)	VIID7	DISTRIBUTIONS OF SCORES ON TESTS	/ 2.39	Z	
(S)	VIID8	ALPHA RELIABILITIES FOR OBJECTIVES AND TESTS	/ 2.57	Z	
(S)	VIID9	RELIABILITY COEFFICIENTS FOR OBJECTIVES AND TESTS	/ 2.40	Z	
	VIIE	CAI EVALUATION DATA			
(S)	VIIE1	CAI, PERCENT SELECTING QUESTION ALTERNATIVES	/ 2.48	CRP,CB, CD,CL,CO	
(S)	VIIE2	CAI, PERCENT SELECTING BY ATTEMPT NUMBER	/ 2.70	CRP,CB, CD,CL,CO	

APPENDIX C (CONTINUED)

			FUNCTION	/ VALUE	FILES NEEDED	CPU TIME
	(S)	VIIE3	CAI, TIMES TO READ AND TO RESPOND	/ 2.88	CRP,CB, CD,CL,CO	
	(S)	VIIE4	CAI, LIST UNANTICIPATED RESPONSES	/ 2.81	CRP,CB, CD,CL,CO	
	(S)	VIIE5	CAI, OPEN-ENDED STUDENT COMMENTS	/ 2.82	CB,CC,CD, CL,CO	
	(S)	VIIE6	CAI, RECORD STUDENT PATH THROUGH LESSON	/ 2.70	CRP,CB, CD,CL,CO	
	(S)	VIIE7	CAI, STATISTICS ON MAJOR UNITS OF PROGRAM	/ 2.65	CRP,CB, CD,CL,CO	
	(S)	VIIF	COURSEWARE DEVELOPMENT MANAGEMENT REPORTS	/ 2.69		
	(S)	VIIG	PERFORMANCE FORECAST REPORTS TO FIELD	/ 2.71	S	
DROP	(S)	VIIG1	PRE-SERVICE EDUCATION, VOCATIONAL TRAINING	/ 2.82	S	
DROP	(S)	VIIG2	PRE-SERVICE OCCUPATION, JOB EXPERIENCE	/ 2.92	S	
DROP	(S)	VIIG3	AF PERSONNEL RECORDS AND DATA - ASVAB, ETC.	/ 2.93	S	
	(S)	VIIG4	IN-SERVICE TRAINING PERFORMANCE DATA	/ 2.87	S	
DROP	(S)	VIIG5	SPECIALTY-RELATED DEFICIENCIES	/ 2.72	S	
DROP	(S)	VIIG6	PREDICT PERFORMANCE IN FIELD ASSIGNMENT	/ 2.92	S	
		VIIH	SPECIAL PURPOSE REPORTS			
DROP	(S)	VIIH1	SPECIAL REPORTS - BASIC DATA RETRIEVAL, BACKGROUND	/ 2.99	B,V,RDF	
DROP	(S)	VIIH2	SPECIAL REPORTS - INTERACTIVE RETRIEVAL	/ 2.83	B,V,RDF	
	(S)	VIIH3	SPECIAL REPORTS - RETRIEVAL WITH STATISTICS	/ 2.74	B,V,RDF	20 MSEC/SEC/ ON-LINE USER
			....INTERACTIVE FROM DISC		B,V,RDF	
			....BATCH ONLY ON-SHIFT		B,V,RDF	
			....BATCH ONLY OFF-SHIFT		B,V,RDF	

APPENDIX C (CONTINUED)

Abbreviations:

cv = course version
s = student
b = block
g = group (group or block)
LC = learning center
L = lesson
M = module

CAI RECORDS

	File	Number of Records	Max. Size (Words)	Size (if variable length)
CL	CAI lesson record	1/module with CAI	257	57 + (# of highest objective x 2)
CO	CAI objective record	1/objective	623	23 + (# of frames x 6)
CB	Branching record	1/objective that has branching (some branching instructions require 3 words)	1012	12 + (# of branches)
CT	Text record, type 1	1/text frame	504	4 + text buffer, average length 25 words
	type 2	1/text frame	506	6 + text buffer, average length 50 words
CRP	Response point record	1/student response	40	16 + (# of unanticipated responses)
CD	Decision point record	1/decision point passed	35	15 + (# of decisions/frame x 2)
CC	Comment record	1/comment recorded	512	12 + buffer, average = 30 words
CSL	Restart record	1/student taking CAI lesson	64	
CSR	Restart record	1/student in CAI review/ remediation	270	65 + ((# of objectives + 4)/5)

APPENDIX C (CONCLUDED)

	File	Number of Records	Max. Size (Words)	Size (if variable length)
A	Absence	1/s/b if absent in block	511	11 + (# cf absences x 2)
B	Block	1/s/b completed this week	1	
C	Course	1/cv	606	
D	Student Data Profile, list of lessons to do	1/s using file		
E	Course Enrollment	1/s	1	
F	Class (Facility)	2/LC	242	2 + (4 x last type defined)
H	Hierarchy of Course	1/g	284	166 + (3 x # of nodes)
I	Item Record (on-line testing)			
K	Test Key	1/test	254	7 + # of subscales + # of items in each subscale
L	Lesson	1/L	14	
M	Module Completion Record	1/s/started block	508	88 + (3 x # of transactions)
N	Module	1/m	222	206 + # of resources
P	Learning Center	1/LC/shift	155	
Q	Queue	366	509	
R	Resource Type Descrip.	1	801	
S	Student Status	1/s	452	422 + # of resources
T	Testing Record	1/s taking test	260	11 + # of items answered
V	Variables Definitions	1/variable	13	
W	Calendar	1/cv	288	
X	Resources Cross-Reference	1/b	156	
Z	CMI	1/transaction	29	
RDF	Recent Data File	400/b/course	688	6100 + # of highest lesson taken

APPENDIX D

ORDERED LISTING OF CAI/CMI FUNCTIONS, ACCORDING TO AVERAGE RATING FROM ATC RESIDENT TECHNICAL TRAINING PARTICIPANTS, WITH DISTRIBUTIONS OF RATING RESPONSES AND PROPORTIONS OF HIGH (1 AND 2) RATINGS

Items are designated as (I), (S), or blank. The (I) items appeared only on the instructor survey form, the (S) items only on the supervisor form, and the blank items appeared on both the instructor and supervisor forms.

NOTE: These means were derived by averaging all of the individual responses, and are therefore somewhat different from the Appendix C means, which were derived by averaging the group averages.

	ITEM		FREQUENCIES, CATEGORIES 1 - 5 AND X						MEAN	PROPORTION OF 1 & 2 RATINGS
			1	2	3	4	5	X		
(S)	VIID4	FLAG ALTERNATIVES MISSED BY X% OR MORE /	43	43	28	10	1	5	2.06	.69
	IA	TEST SCORING AND FEEDBACK /	86	81	55	21	7	17	2.13	.67
(I)	IIF1	ASSIGN SUPPLEMENTARY TRNG BASED ON ENTRY SKILLS /	50	36	25	7	10	9	2.15	.67
	VIIA2C	OBJECTIVES FAILED IN BLOCK /	76	91	59	19	9	13	2.19	.66
(S)	VIID2	TIMES EACH QUESTION IS ANSWERED CORRECTLY /	35	45	33	10	2	5	2.19	.64
(I)	IA1	RIGHT-WRONG WITH PERCENT CORRECT /	46	30	31	12	5	13	2.19	.61
(I)	IIF2	ASSIGN SUPPL. TRNG BASED ON LEARNING SKILLS /	47	35	25	8	11	11	2.21	.65
(S)	IB	ADD'L ON-LINE TEST CAPABILITIES /	36	44	32	12	2	4	2.21	.63
(S)	VIID	TEST ITEM EVALUATION REPORT /	24	35	33	5	1	32	2.22	.60
(I)	VIC4	FEEDBACK FOR RIGHT/WRONG, AS SELECTED /	36	40	23	10	7	21	2.24	.66
	VIF	USE EDITORS FOR COURSE DOCUMENTATION /	77	66	48	19	16	41	2.25	.63
(S)	VIID1	TIMES EACH ALTERNATIVE IS SELECTED /	33	44	34	11	3	5	2.26	.62
	VIIA2	BLOCK PROGRESS REPORTS /	72	70	78	17	10	20	2.28	.57
	IIF	ASSIGN TO SUPPL. SKILL TRAINING ON ENTRY /	73	83	53	24	16	18	2.31	.63
(I)	IA5	PASS SPECIFIC OBJECTIVES /	42	34	27	12	10	12	2.31	.61
	VIB	AUTOMATIC VALIDATION OF COURSE DATA BASE /	61	84	57	22	12	31	2.32	.61
	VIE6	CONDUCT ON-LINE TRYOUTS /	63	80	61	22	11	30	2.32	.60
	VIIA4C	ADD'L REPORT: ON-LINE DISPLAY OF STUDENT DATA /	75	76	64	25	15	12	2.33	.59
	VIIA2D	TIMES ON LESSONS AND BLOCKS /	68	78	73	28	8	12	2.33	.57

APPENDIX D (CONTINUED)

	ITEM			FREQUENCIES, CATEGORIES 1 - 5 AND X						MEAN	PROPORTION OF 1 & 2 RATINGS
				1	2	3	4	5	X		
	VIIA	REPORTS FOR INSTRUCTORS	/	67	70	82	18	11	19	2.34	.55
(I)	IC3	LEARNING PROCESS SKILLS	/	37	39	31	10	10	10	2.35	.60
(S)	VIID9	RELIABILITY COEFFIC. FOR OBJECTIVES AND TESTS	/	27	37	36	9	4	17	2.35	.57
(S)	VIID7	DISTRIBUTIONS OF SCORES ON TESTS	/	26	43	45	8	3	5	2.35	.55
(I)	IID1	ASSIGN TO ALTERNATE LESSON REMEDIATION	/	33	41	32	6	11	14	2.36	.60
	VIIA3D	OBJECTIVES FAILED MORE THAN TWICE	/	70	82	58	27	16	14	2.36	.60
	IVA	IDENTIFY STUDENTS NEEDING SPECIAL ATTENTION	/	64	84	55	34	11	19	2.37	.60
	IVB	IDENTIFY MARGINAL PERFORMANCE IN COURSE	/	61	91	58	29	13	15	2.37	.60
(I)	IVB3	FLAGGED FOR ELIMINATION FROM TRAINING	/	38	38	28	12	11	10	2.37	.60
(I)	IVB4	FLAGGED FOR SPECIAL REMEDIAL TRAINING	/	33	41	32	10	9	12	2.37	.59
(S)	VIC	EDITORS FOR PRODUCING ON-LINE TESTS	/	22	47	39	11	2	9	2.37	.57
(I)	IC2	PRE-COURSE KNOWLEDGE TESTING	/	34	38	37	12	7	9	2.38	.56
	VIIA2A	LESSONS STUDENT HAS COMPLETED	/	67	77	64	34	12	13	2.40	.57
	VIE4	PRINT MASTER COPY FOR OFF-LINE MATERIALS	/	60	76	64	22	16	29	2.40	.57
	VIE5	PRINT MULTIPLE COPIES FOR TRYOUTS	/	66	66	65	26	15	29	2.40	.55
	VIIA2B	ATTEMPTS AND SCORES ON LESSONS	/	63	85	60	33	14	12	2.41	.58
(I)	IC4	COURSE-SPECIFIC ENTRY SKILLS	/	36	35	34	12	10	10	2.41	.56
(I)	IB1	ON-LINE WITH RANDOM QUESTION ORDERS	/	37	30	35	10	11	14	2.41	.54
	IIIA	SCHEDULE STUDENT ENTRIES TO COURSE	/	68	77	50	22	25	25	2.42	.60
	VID5	CAI AUTHOR HAS "HELP" FRAMES WITH EDITORS	/	44	85	54	23	12	49	2.42	.59
(I)	IB2	ON-LINE, RANDOM ORDERS FOR ALTERNATIVES	/	36	30	36	11	10	14	2.42	.54
(I)	IID2	ASSIGN TO ALT. LESSON GROUPS REMEDIATION	/	32	39	29	10	12	15	2.43	.58
	VA	CAI APPLICATIONS, TRAINING AND TESTING	/	55	73	65	25	13	36	2.43	.55
	VIIA1	LEARNING CENTER ROSTERS	/	72	60	72	36	12	15	2.43	.52
(I)	IA4	PASS CERTAIN PERCENT OF OBJECTIVES	/	36	35	33	11	13	9	2.45	.55
(S)	VIID3	FOR ALTERNATIVES, AVERAGE TEST SCORES	/	26	38	40	17	3	6	2.46	.52
	VIIA3	STUDENT HISTORY REPORTS	/	53	70	76	27	12	29	2.47	.52
(I)	IIE2	TEST ASSIGN. EXCLUDES PREVIOUSLY TAKEN VERSIONS	/	34	37	22	12	15	17	2.48	.59

APPENDIX D (CONTINUED)

	ITEM			FREQUENCIES, CATEGORIES 1 - 5 AND X						MEAN	PROPORTION OF 1 & 2 RATINGS*
				1	2	3	4	5	X		
(I)	IVA2	PROFIC. AND DEFIC. SCORES PRINTED OUT	/	27	41	35	11	10	13	2.48	.55
	VIIA3B	SCORES ON ENTRY SKILLS	/	59	77	74	24	21	12	2.49	.53
(I)	IVA3	SCORES ON CRITICAL ENTRY VARIABLES PRINTED OUT	/	32	31	37	14	9	14	2.49	.51
(S)	VIIE1	CAI, SELECTING EACH ALTERNATIVE	/	20	42	44	11	5	8	2.50	.51
(I)	IC1	RELEVANT AF PERSONNEL DATA	/	32	32	41	14	9	9	2.50	.50
(I)	VIC2	RANDOMIZED QUESTIONS AND ALTERNATIVES	/	23	42	27	14	9	22	2.51	.57
	IIIB	GRADUATION FORECASTING	/	57	71	54	28	22	35	2.51	.55
	VID2	CAI AUTH., FORMATS TEXT FRAMES AND QUESTIONS	/	41	74	58	28	12	54	2.51	.54
(I)	VC1	CAI: STUDENT SKILL TRAINING	/	24	38	32	15	7	21	2.51	.53
(I)	VIC1	AUTOMATIC FORMAT FOR TEST QUESTION ENTRY	/	22	36	37	11	7	24	2.51	.51
(I)	VA5	CAI FOR BLOCK REMEDIATION	/	32	33	22	17	12	21	2.52	.56
	VID4	CAI AUTH., COPIES FRAMES FROM OTHER LESSONS	/	38	80	64	27	12	46	2.52	.53
	VID3	CAI AUTH., STRUCTURES SEQUENCE OF FRAMES	/	39	70	66	27	10	55	2.52	.51
	VID1	CAI AUTHORING EDITOR, NOT TEAM WRITING	/	40	72	65	23	14	53	2.53	.52
(S)	VIIB7	REPORT, INSTRUCTOR UTILIZATION AND PERFORMANCE	/	24	40	36	16	7	7	2.53	.52
	VIIA2E	TIME AHEAD OR BEHIND SCHEDULE	/	58	72	74	32	18	13	2.53	.51
	IC	PREASSESSMENT DATA CAN BE USED	/	56	66	75	26	19	25	2.53	.50
(I)	IID3	ASSIGN TO BLOCK AND COURSE REMEDIATIONS	/	32	36	28	8	18	15	2.54	.56
(I)	IVA1	FLAGGED ON ENTRY VARIABLES	/	28	39	28	18	10	14	2.54	.54
(S)	VIID5	ITEM REMAINDER CORRELATIONS	/	20	34	42	15	3	16	2.54	
(S)	VIID8	ALPHA RELIABILITIES FOR OBJECTIVES AND TESTS	/	23	27	40	13	5	22	2.54	
	VID6	CAI AUTH., "HELPS" FOR WRITING PRACTICES	/	44	75	50	33	16	49	2.55	.55
(S)	VIIB8	REPORT, STUDENT TIMES AND GRADES BY BLOCKS	/	22	40	33	18	6	11	2.55	.52
(S)	VIIC	COURSE EVALUATION SUMMARY	/	19	38	43	8	8	14	2.55	
(S)	VIID6	MEAN AND SD OF SCORES BY OBJECTIVE AND TEST	/	22	35	46	14	5	8	2.55	
	IIIB4	DIRECT INTERFACE TO CBPO COMPUTER	/	54	69	43	40	19	42	2.56	.55
(I)	IIB3	ORDER BASED ON RESOURCE AVAILABILITY	/	28	38	30	19	10	12	2.56	.53
(I)	VC2	CAI: INSTRUCTOR SKILL TRAINING	/	26	36	29	15	11	20	2.56	.53

* A blank in this column indicates that less than half of the participants rating an item assigned a rating of 1 or 2.

APPENDIX D (CONTINUED)

	ITEM			FREQUENCIES, CATEGORIES 1 - 5 AND X							PROPORTION OF 1 & 2 RATINGS*
				1	2	3	4	5	X	MEAN	
	VIE3	CAI AUTH., USE TO REVIEW/REVISE OFF-LINE MAT'LS	/	40	84	63	26	19	35	2.57	.53
(I)	IVB2	MARGINAL TIMES AND SCORES PRINTED OUT	/	31	31	35	14	13	13	2.57	.50
	VIE	CAI AUTH., USE FOR OFF-LINE MATERIALS	/	42	69	68	29	14	45	2.57	.50
	IIB	DETERMINE ORDER OF ASSIGNMENTS	/	42	79	80	26	17	23	2.58	
(I)	IIG	RESOURCE MANAGEMENT BY COMPUTER	/	26	31	40	11	11	18	2.58	
(I)	VIC3	CONTROL NO. OF ATTEMPTS PER QUESTION	/	23	35	31	13	11	24	2.59	.51
(S)	VIIC2	FINAL TIMES AND SCORES	/	16	47	40	14	7	6	2.59	.51
(S)	VIIB6	REPORT, RESOURCE UTILIZATION	/	25	32	41	19	7	6	2.60	
(I)	IIB1	ORDER BASED ON LESSONS COMPLETED	/	30	30	41	12	14	10	2.61	
(S)	IID	ASSIGN TO ALTERNATE REMEDIATIONS	/	18	42	36	17	7	10	2.61	.50
	VIIA3C	TIMES IN BLOCK REMEDIATION	/	53	64	82	42	14	12	2.61	
	VIIA4A	ADD'L REPORT: ABSENCE REPORT	/	59	69	65	34	27	13	2.61	.50
(S)	VIIE7	CAI, STAT. ON MAJOR UNITS OF A PROGRAM	/	21	27	56	14	4	8	2.61	
(I)	IVB1	FLAGGED ON TIME AND SCORE VARIABLES	/	25	33	42	15	10	12	2.62	
	VIIA3E	ABSENCE TIMES AND REASONS, BY BLOCKS	/	53	67	74	35	23	15	2.63	
(S)	VIIB2	REPORT, STUDENTS BY BLOCK, ROOM, OR BASE	/	20	43	36	17	10	4	2.63	.50
	VIE1	CAI AUTH., FOR OFF-LINE TESTS	/	36	84	63	27	23	34	2.64	.52
(I)	IIB2	ORDER BASED ON EARLIER PERFORMANCE	/	24	36	38	11	15	13	2.65	
	IIIB5	GRADUATES: SCHEDULE OUT-PROCESSING	/	53	58	55	34	26	41	2.65	
(I)	VA6	CAI FOR TEACHING STUDY SKILLS	/	26	31	28	19	12	21	2.66	
	VIE2	CAI AUTH., FOR OFF-LINE LESSONS	/	36	82	60	30	23	36	2.66	.51
(I)	IA3	WEIGHT QUESTIONS DIFFERENTIALLY	/	22	41	34	8	18	14	2.67	.51
	IIIB3	GRADUATION REPORTS TO CBPO	/	51	61	53	38	25	39	2.67	
	VC	CAI: LEARNING PROCESS, SPECIAL SKILLS TRNG	/	43	62	75	34	19	34	2.67	
	VIA2	GRAPHICS FOR COURSE STRUCTURE DISPLAY	/	45	53	76	36	16	41	2.67	
	VIIA2F	HOMEWORK ACCOMPLISHED	/	54	59	77	39	22	16	2.67	
	ID	ATTITUDES AND INTERESTS	/	47	58	79	38	18	27	2.68	

* A blank in this column indicates that less than half of the participants rating an item assigned a rating of 1 or 2.

APPENDIX D (CONTINUED)

	ITEM		FREQUENCIES, CATEGORIES 1 - 5 AND X 1	2	3	4	5	X	MEAN	PROPORTION OF 1 & 2 RATINGS*
(S)	VIIC1	FIRST ATTEMPT TIMES AND SCORES	/ 15	39	47	15	8	6	2.69	
(S)	VIIC10	FIRST ATTEMPT OBJECTIVE FAIL RATES	/ 21	26	52	16	7	8	2.69	
(I)	VA4	CAI FOR BLOCK REVIEW	/ 23	30	34	17	12	21	2.70	
(S)	VIIC8	SCORE DATA BY OBJECTIVES IN LESSONS	/ 20	28	51	17	7	7	2.70	
(S)	VIIC9	FIRST ATTEMPT LESSON FAIL RATES	/ 20	27	51	17	7	8	2.70	
	IIC	ASSIGN TO ALTERNATE LESSONS	/ 38	76	67	34	24	28	2.71	
(I)	IIIB2	REPORT: GRADUATES IN NEXT N DAYS	/ 25	33	26	17	16	20	2.71	
(S)	VIIB3	REPORT: DISTRIBUTIONS OF BLOCK TIMES	/ 18	28	52	22	3	7	2.71	
(S)	VIIH3	BASIC DATA RETRIEVAL PLUS STATISTICS	/ 13	27	44	13	5	28	2.71	
(S)	VIIB4	REPORT: DISTRIBUTIONS OF COURSE TIMES	/ 17	35	41	25	5	7	2.72	
(S)	VIIG5	SPECIALTY-RELATED DEFICIENCIES	/ 20	30	42	19	9	10	2.73	
(I)	IVA4	PREDICTED COMPLETION TIMES, PROFIC/DEFIC	/ 19	32	41	19	10	16	2.74	
	VB7	CAI: INTERFACE WITH CMI DATA BASE	/ 43	59	65	40	23	37	2.74	
(S)	VIIH2	BASIC DATA RETRIEVAL, INTERACTIVE	/ 9	30	48	13	4	26	2.74	
(I)	IIG1	RESOURCE MGMT: ASSIGNMENT TO LEARNING CENTERS	/ 22	27	45	16	12	15	2.75	
(S)	VIIC12	SUMMARY, FAIL RATE ABOVE X PERCENT	/ 18	29	52	11	12	8	2.75	
(S)	VIIE6	CAI, RECORD STUDENT PATH THROUGH LESSON	/ 17	29	47	21	6	10	2.75	
(I)	IIC4	IN-COURSE PERFORMANCE DETERMINES ASSIGNMENT	/ 28	28	31	17	19	14	2.76	
(S)	VIIE2	CAI, SELECTING BY ATTEMPT NUMBER	/ 15	32	47	21	6	9	2.76	
	VB2	CAI, ADD GRAPHICS CAPABILITIES	/ 39	71	63	37	29	28	2.77	
	VB6	CAI, CONTROL OF SLIDE, FILM PROJECTOR	/ 45	60	64	45	25	28	2.77	
(S)	VIIB1	REPORT, STUDENTS AWAITING TRAINING	/ 21	31	41	20	12	5	2.77	
(S)	VIIG	PERFORMANCE FORECAST REPORTS TO FIELD	/ 20	28	43	22	9	8	2.77	
(I)	IIIC4	MANAGEMENT TARGETS FROM WITHIN-COURSE DATA	/ 21	25	38	18	12	23	2.78	
(I)	IIB4	ORDER BASED ON TEAMING CONSIDERATIONS	/ 21	34	24	14	19	25	2.79	
(I)	VA2	CAI TUTORIAL	/ 26	22	28	22	14	25	2.79	

* A blank in this column indicates that less than half of the participants rating an item assigned a rating of 1 or 2.

APPENDIX D (CONTINUED)

	ITEM			FREQUENCIES, CATEGORIES 1 - 5 AND X						MEAN	PROPORTION OF 1 & 2 RATINGS*
				1	2	3	4	5	X		
	VB5	CAI, CONTROL OF AUDIO TAPE PLAYER	/	41	59	66	41	26	34	2.79	
	VIA1	ON-LINE CMI DATA BASE EDITING	/	36	46	66	39	18	62	2.79	
	VIIA4B	ADD'L REPORT: HOMEWORK SUMMARY	/	44	57	87	36	28	15	2.79	
(S)	VIIF	COURSEWARE DEVELOPMENT MANAGEMENT REPORTS	/	17	27	47	18	9	12	2.79	
(I)	IIC1	INSTRUCTOR ASSIGNS ALTERNATES	/	15	39	36	21	12	14	2.80	
(I)	IIIB1	PREDICTED GRADUATION DATES ON ROSTERS	/	23	31	30	14	20	19	2.81	
(I)	ID1	PRE AND POST ATTITUDES	/	22	28	38	24	13	12	2.82	
	VIIA3A	ATTITUDE AND INTEREST INFORMATION	/	43	59	78	45	27	15	2.82	
	IIA	ASSIGN TO ALTERNATE COURSE VERSIONS	/	40	63	66	33	35	30	2.83	
(I)	IIC5	PRE-COURSE MEASURES DETERMINE ASSIGNMENTS	/	23	28	37	14	20	15	2.84	
(I)	IB4	ON-LINE, CONSTRUCTED RESPONSES	/	29	21	29	16	23	19	2.85	
(I)	IIC3	RESOURCES DICTATE ALTERNATE ASSIGNMENTS	/	23	25	39	19	17	14	2.85	
(S)	VIIE4	CAI, LIST UNANTICIPATED RESPONSES	/	13	27	51	20	8	11	2.85	
(S)	VIIE5	CAI, OPEN-ENDED STUDENT COMMENTS	/	13	27	55	17	9	9	2.85	
(S)	VIIG1	PRE-SERVICE EDUCATION OR VOCATIONAL TRNG	/	14	32	45	26	8	5	2.85	
(I)	ID2	WITHIN-COURSE ATTITUDES AND INTERESTS	/	23	26	40	19	18	11	2.87	
	IIE	TESTS SELECTED AND ASSIGNED	/	35	55	84	39	27	27	2.87	
(I)	IIE1	TEST ASSIGNMENT AT RANDOM	/	20	36	29	18	21	13	2.87	
	IIIC	MANAGE STUDENT TO TARGET	/	27	66	90	32	28	24	2.87	
(S)	VIIG4	IN-SERVICE TRAINING PERFORMANCE DATA	/	15	26	45	26	7	11	2.87	
(I)	VA1	CAI DRILL AND PRACTICE	/	23	23	26	16	20	29	2.88	
	VB3	CAI, ADD CONSTRUCTED RESPONSES	/	33	60	70	43	27	34	2.88	
(S)	VIIC11	CORRELATIONS, ACTUAL WITH PREDICTED TIME, SCORE	/	15	23	58	15	12	7	2.89	
(S)	VIIG3	AF PERSONNEL DATA - ASVAB, ETC.	/	17	32	39	18	17	7	2.89	
(I)	VA3	CAI SIMULATION	/	23	19	25	23	16	31	2.91	
(S)	VIIE3	CAI, TIMES TO READ AND TO RESPOND	/	11	27	49	26	6	11	2.91	
(I)	IIIC1	MANAGEMENT TARGETS PRINTED FOR ENTIRE COURSE	/	18	27	37	21	16	18	2.92	

* A blank in this column indicates that less than half of the participants rating an item assigned a rating of 1 or 2.

APPENDIX D (CONCLUDED)

	ITEM		FREQUENCIES, CATEGORIES 1 - 5 AND X							PROPORTION OF 1 & 2
			1	2	3	4	5	X	MEAN	RATINGS*
(S)	VIIC6	MEAN, SD FOR LESSON & BLOCK COMPLET. TIMES	13	29	43	25	10	10	2.92	
(S)	VIIG2	PRE-SERVICE OCCUPATION & JOB EXPERIENCE	16	28	44	26	12	4	2.92	
(I)	IB5	ON-LINE, ADAPTIVE WITHIN TEST	21	28	30	14	24	20	2.93	
(S)	VIIH1	BASIC DATA RETRIEVAL, BACKGROUND MODE	7	24	48	19	6	26	2.93	
(I)	IIG3	MANAGE RESOURCES ACROSS LEARNING CENTERS	16	26	39	15	19	22	2.95	
(S)	VIIC4	MEAN, SD FOR FINAL LESSON AND BLOCK SCORES	12	27	47	25	10	9	2.95	
(S)	VIIC5	MEAN, SD FOR 1ST ATTEMPT LESSON, BLOCK SCORES	12	26	48	24	10	10	2.95	
	VB4	CAI, ADD TOUCH PANEL OR LIGHT PEN	31	57	53	51	30	45	2.96	
(S)	VIIC3	MEAN, SD, 1ST ATTEMPT TIMES AND SCORES	12	23	52	24	9	10	2.96	
(I)	IIC7	PERFORMANCE PREDICTION DETERMINES ASSIGNMENTS	18	24	37	20	18	20	2.97	
(I)	IIIC2	MGMT. TARGETS PRINTED FOR INDIVIDUAL BLOCKS	19	18	42	20	16	22	2.97	
(S)	VIIC7	SCORE AND TIME DATA BY LESSON ALTERNATES	13	20	57	18	12	10	2.97	
(I)	IIB5	ORDER SELECTED BY INSTRUCTOR	13	34	37	15	21	17	2.98	
(S)	VIIG6	PREDICT ADAPT, PERFORMANCE IN FIELD ASSIGNMENT	17	22	45	21	16	9	2.98	
(I)	IIG2	RESOURCES: ASSIGN TO OPTIMIZE ACROSS BLOCKS	15	28	40	23	18	13	3.01	
(I)	IIE3	ASSIGNMENT TO ON- OR OFF-LINE TESTS	19	19	37	25	17	20	3.02	
(I)	IIIC5	MGMT. TARGETS, RELATIVE TO AVERAGE CRSE. LENGTH	15	18	43	20	15	26	3.02	
(S)	VIIB5	REPORT PERFORMANCES BY ROOMS OR BY BASES	14	25	40	28	14	9	3.02	
(I)	IB3	ON-LINE, RETEST OVER FAILED OBJECTIVES	25	25	25	17	31	14	3.03	
(I)	IIIC6	MGMT. TARGETS, RELATIVE TO POI LENGTH	14	13	45	26	10	29	3.05	
(I)	IB6	ON-LINE, ADAPTIVE ON COURSE PERFORMANCE	18	27	32	14	28	18	3.06	
(I)	IA7	SCORE PERFORMANCE CHECKLISTS	29	16	31	15	34	12	3.07	
(I)	IIIC3	MGMT. TARGETS BASED ON PRE-COURSE DATA	16	14	41	25	15	26	3.08	
	VB1	CAI, BASIC CAI CAPABILITIES	21	39	87	57	34	29	3.18	
(I)	IA2	CORRECT SCORE FOR GUESSING	18	18	30	20	28	23	3.19	
(I)	IA8	INSTRUCTOR CAN CERTIFY LESSON PASS	14	22	27	20	32	22	3.30	
(I)	IA6	PASS SPECIFIC QUESTIONS	18	17	32	20	35	15	3.30	
(I)	IIC6	HEURISTIC RULES FOR ASSIGNMENT SELECTION	5	24	41	23	26	18	3.34	
(I)	IIC2	STUDENTS SELECT DESIRED ALTERNATIVES	10	11	32	26	44	14	3.67	

* A blank in this column indicates that less than half of the participants rating an item assigned a rating of 1 or 2.

APPENDIX E

--SURVEY OF CAI/CMI FUNCTIONS--

Listing of functions and mean ratings from Air Force training other than resident technical: Field training detachments/on-the-job training (FTD/OJT); Undergraduate Navigator Training (UNT); Air University (AU); and HQ ATC DO, Pilot Training (PT).

Items are designated as (I), (S), or blank. The (I) items appeared only on the instructor survey form; the (S) items appeared only on the supervisor forms; and the blank items appeared on both instructor and supervisor forms.

One supervisory participant from ATC HQ DO (Pilot Training) represented the views of that organization. The participants from Air University were all supervisory personnel. From these locations, there are no ratings for the items which were only on the instructor survey form.

				MEAN RATINGS			
		FUNCTION	/	FTD/OJT	UNT	PT	AU
I -	STUDENT TESTING AND EVALUATION	###################################	###	##########	##########	#####	#####
	IA	TEST SCORING AND FEEDBACK	/	2.08	2.33	3.00	2.29
(I)	IA1	RIGHT-WRONG WITH PERCENT CORRECT	/	2.42	1.50		
(I)	IA2	CORRECT SCORE FOR GUESSING	/	2.17	4.00		
(I)	IA3	WEIGHT QUESTIONS DIFFERENTIALLY	/	2.33	2.50		
(I)	IA4	PASS CERTAIN PERCENT OF OBJECTIVES	/	2.08	2.00		
(I)	IA5	PASS SPECIFIC OBJECTIVES	/	2.00	1.00		
(I)	IA6	PASS SPECIFIC QUESTIONS	/	3.00	2.50		
(I)	IA7	SCORE PERFORMANCE CHECKLISTS	/	2.83	2.00		
(I)	IA8	INSTRUCTOR CAN CERTIFY LESSON PASS	/	2.58	3.50		
(S)	IB	ADDITIONAL ON-LINE TEST CAPABILITIES	/	2.62	2.38	3.00	2.89
(I)	IB1	ON-LINE, RANDOM QUESTION ORDERS	/	2.17	2.50		
(I)	IB2	ON-LINE, RANDOM ORDERS OF ALTERNATIVES	/	2.25	2.50		
(I)	IB3	ON-LINE, RETEST OVER FAILED OBJECTIVES	/	2.58	2.50		
(I)	IB4	ON-LINE, CONSTRUCTED RESPONSES	/	2.83	2.50		
(I)	IB5	ON-LINE, ADAPTIVE WITHIN TEST	/	2.90	2.00		
(I)	IB6	ON-LINE, ADAPTIVE ON COURSE PERFORMANCE	/	2.58	2.50		

APPENDIX E (CONTINUED)

		FUNCTION	/	MEAN RATINGS FTD/OJT	UNT	PT	AU
	IC	PREASSESSMENT DATA CAN BE USED	/	3.35	3.17	4.00	2.59
(I)	IC1	RELEVANT AF PERSONNEL DATA	/	2.75	3.00		
(I)	IC2	PRECOURSE KNOWLEDGE TESTS	/	2.58	2.50		
(I)	IC3	LEARNING PROCESS SKILLS	/	2.50	3.00		
(I)	IC4	COURSE-SPECIFIC ENTRY SKILLS	/	2.42	2.00		
	ID	ATTITUDES AND INTERESTS	/	3.05	3.42		
(I)	ID1	PRE AND POST ATTITUDES	/	2.58	2.50		
(I)	ID2	WITHIN COURSE ATTITUDES AND INTERESTS	/	2.67	2.00		

II - STUDENT ASSIGNMENT ##

		FUNCTION	/	FTD/OJT	UNT	PT	AU
	IIA	ASSIGN TO ALTERNATE COURSE VERSIONS	/	2.98	2.58	3.00	3.39
	IIB	DETERMINE ORDER OF ASSIGNMENTS	/	2.97	2.42	3.00	3.50
(I)	IIB1	ORDER BASED ON LESSONS COMPLETED	/	2.83	2.00		
(I)	IIB2	ORDER BASED ON EARLIER PERFORMANCE	/	2.67	2.50		
(I)	IIB3	ORDER BASED ON RESOURCE AVAILABILITY	/	2.50	1.50		
(I)	IIB4	ORDER BASED ON TEAM CONSIDERATIONS	/	2.95	2.00		
(I)	IIB5	ORDER SELECTED BY INSTRUCTOR	/	2.83	1.50		
	IIC	ASSIGN TO ALTERNATE LESSON TREATMENTS	/	3.00	1.92	2.00	3.69
(I)	IIC1	INSTRUCTOR ASSIGNS ALTERNATES	/	3.20	2.00		
(I)	IIC2	STUDENT SELECTS DESIRED ALTERNATES	/	3.35	3.00		
(I)	IIC3	RESOURCES DICTATE ALTERNATE ASSIGNMENT	/	2.95	3.00		
(I)	IIC4	IN-COURSE PERFORM. DETERMINES ASSIGNMENT	/	2.85	1.50		
(I)	IIC5	PRE-COURSE MEASURES DETERMINE ASSIGNMENT	/	2.65	3.00		
(I)	IIC6	HEURISTIC RULES FOR ASSIGNMENT SELECTION	/	2.60	4.00		
(I)	IIC7	PERFORMANCE PREDICTION DETERMINES ASSIGNMENT	/	2.75	1.50		
(S)	IID	ASSIGN TO ALTERNATE REMEDIATIONS	/	2.85	2.50	3.00	3.29
(I)	IID1	ASSIGN TO ALTERNATE LESSON REMEDIATION	/	3.08	4.00		
(I)	IID2	ASSIGN TO ALTERNATE LESSON GRPS REMEDIATION	/	2.67	3.50		
(I)	IID3	ASSIGN TO BLOCK OR COURSE REMEDIATIONS	/	2.92	3.50		
	IIE	TESTS SELECTED AND ASSIGNED	/	2.98	3.00	2.00	3.89
(I)	IIE1	TEST ASSIGNMENT AT RANDOM	/	3.33	4.00		
(I)	IIE2	TEST ASSIGN. EXCLUDES PREVIOUSLY TAKEN TESTS	/	3.17	2.50		

APPENDIX E (CONTINUED)

		FUNCTION	/	MEAN RATINGS FTD/OJT	UNT	PT	AU
(I)	IIE3	ASSIGNMENT TO ON- OR OFF-LINE TESTS	/	3.20	3.50		
	IIF	ASSIGN. TO SUPPLEMENTARY SKILL TRAINING ON ENTRY	/	2.76	2.67	4.00	3.39
(I)	IIF1	ASSIGN. SUPPLEMENTARY TRAINING BASED ON ENTRY SKILLS	/	2.25	1.50		
(I)	IIF2	ASSIGN SUPPLEMENTARY TRAINING ON LEARNING SKILLS	/	2.80	2.00		
(I)	IIG	RESOURCE MANAGEMENT BY COMPUTER	/	2.35	2.00		
(I)	IIG1	RESOURCES: ASSIGN TO LEARNING CENTERS	/	3.20	2.00		
(I)	IIG2	RESOURCES: ASSIGN TO OPTIMIZE ACROSS BLOCKS	/	3.45	2.00		
(I)	IIG3	RESOURCES: MANAGE OUTSIDE LEARNING CENTER	/	3.30	1.50		
III - STUDENT PROGRESS MANAGEMENT ##							
	IIIA	SCHEDULE STUDENT ENTRIES TO COURSE	/	3.12	2.00	--	4.33
	IIIB	GRADUATION FORECASTING	/	3.05	3.17	5.00	4.33
(I)	IIIB1	PREDICTED GRADUATION DATES ON ROSTER	/	3.08	1.50		
(I)	IIIB2	GRADUATES IN NEXT N DAYS, LISTED ON REPORT	/	2.67	1.50		
	IIIB3	GRADUATION REPORTS FOR CBPO	/	2.77	3.44	5.00	4.11
	IIIB4	DIRECT INTERFACE TO PERSONNEL SYSTEM	/	2.69	3.33	5.00	3.88
	IIIB5	GRADUATES: SCHEDULE OUT-PROCESSING	/	3.15	2.63	--	4.22
	IIIC	MANAGE STUDENT TO TARGET	/	3.22	3.33	5.00	3.59
(I)	IIIC1	MANAGEMENT TARGETS PRINTED FOR WHOLE COURSE	/	2.67	2.00		
(I)	IIIC2	MANAGEMENT TARGETS PRINTED FOR INDIVIDUAL BLOCKS	/	3.00	2.00		
(I)	IIIC3	MANAGEMENT TARGETS BASED ON PRE-COURSE DATA	/	3.00	4.00		
(I)	IIIC4	MANAGEMENT TARGETS, FROM WITHIN-COURSE DATA	/	3.03	2.50		
(I)	IIIC5	MANAGEMENT TARGETS RELATIVE TO AVERAGE COURSE LENGTH	/	3.00	2.00		
(I)	IIIC6	MANAGEMENT TARGETS, RELATIVE TO POI LENGTHS	/	3.00	2.50		
IV - SUPPORT FOR GUIDANCE AND COUNSELING ##							
	IVA	IDENTIFY STUDENTS NEEDING SPECIAL ATTENTION	/	3.03	2.38	--	2.79
(I)	IVA1	FLAGGED ON ENTRY VARIABLES	/	2.92	4.00		
(I)	IVA2	PROFICIENCY AND DEFICIENCY SCORES PRINTED	/	2.67	4.00		
(I)	IVA3	SCORES ON CRITICAL ENTRY VARIABLES PRINTED	/	2.58	3.00		
(I)	IVA4	PREDICTED COMPLETION TIMES, PROFICIENT-DEFICIENT	/	3.00	4.00		

APPENDIX E (CONTINUED)

				MEAN RATINGS			
		FUNCTION	/	FTD/OJT	UNT	PT	AU
	IVB	IDENTIFY MARGINAL PERFORMANCE IN COURSE	/	2.91	2.25	3.00	3.09
(I)	IVB1	FLAGGED ON TIME AND SCORE VARIABLES	/	2.67	1.50		
(I)	IVB2	MARGINAL TIMES AND SCORES PRINTED OUT	/	2.75	2.00		
(I)	IVB3	FLAGGED FOR ELIMINATION FROM TRAINING	/	2.83	2.00		
(I)	IVB4	FLAGGED FOR SPECIAL REMEDIAL TRAINING	/	2.67	3.00		
V - COMPUTER-AIDED INSTRUCTION (CAI) ##							
	VA	CAI APPLICATIONS, TRAINING AND TESTING	/	2.87	2.42	2.00	3.00
(I)	VA1	CAI DRILL AND PRACTICE	/	3.08	4.00		
(I)	VA2	CAI TUTORIAL	/	2.83	1.00		
(I)	VA3	CAI SIMULATION (LIMITED CAPABILITY)	/	2.92	1.50		
(I)	VA4	CAI FOR BLOCK REVIEW	/	2.75	1.00		
(I)	VA5	CAI FOR BLOCK REMEDIATION	/	2.92	2.00		
(I)	VA6	CAI FOR TEACHING STUDY SKILLS	/	3.42	2.50		
	(VB	CAI CAPABILITIES)...					
	VB1	CAI: BASIC CAI CAPABILITIES	/	3.12	3.58	5.00	3.11
	VB2	BASIC CAI PLUS GRAPHIC CAPABILITIES	/	3.12	2.89	4.00	3.44
	VB3	BASIC CAI PLUS CONSTRUCTED RESPONSE CAPABILITIES	/	2.85	2.67	3.00	3.66
	VB4	BASIC CAI PLUS TOUCH PANEL OR LIGHT PEN	/	3.17	2.44	3.00	3.88
	VB5	BASIC CAI PLUS CONTROL OF AUDIO TAPE PLAYER	/	2.82	3.08	3.00	3.44
	VB6	BASIC PLUS CONTROL OF SLIDE, FILM PROJECTOR	/	2.83	2.33	2.00	3.55
	VB7	BASIC PLUS INTERFACE WITH THE CMI DATA BASE	/	2.93	2.25	2.00	3.77
	VC	CAI FOR TRAINING ON LRNG PROCESSES, SPEC SKILLS	/	3.05	2.50	3.00	3.00
(I)	VC1	CAI FOR STUDENT SKILL TRAINING	/	2.58	2.50		
(I)	VC2	CAI FOR INSTRUCTOR SKILL TRAINING	/	2.75	3.50		
VI - CMI DATA BASE AND CAI MATERIALS PRODUCTION AND MAINTENANCE ##							
	(VIA	CMI COURSE DEFINITION DATA BASE EDITING)					
	VIA1	ON-LINE CMI DATA BASE EDITING	/	3.05	2.33	1.00	3.19
	VIA2	GRAPHICS FOR COURSE STRUCTURE DISPLAY	/	2.73	2.22	2.00	3.22

APPENDIX E (CONTINUED)

			MEAN RATINGS			
	FUNCTION	/	FTD/OJT	UNT	PT	AU
VIB	AUTOMATIC VALIDATION OF COURSE DATA BASE	/	2.25	2.17	2.00	2.69
(S) VIC	EDITORS FOR PRODUCING ON-LINE TESTS	/	3.02	2.88	3.00	2.89
(I) VIC1	AUTOMATIC FORMAT FOR ENTRY OF TEST QUESTIONS	/	2.45	2.00		
(I) VIC2	RANDOMIZED QUESTIONS AND ALTERNATIVES	/	2.35	2.50		
(I) VIC3	CONTROL NUMBER OF ATTEMPTS PER QUESTION	/	2.50	2.50		
(I) VIC4	FEEDBACK FOR RIGHT, WRONG, IF DESIRED	/	2.25	2.00		
(VID	CAI AUTHORING EDITOR)					
VID1	PROVIDE AUTHORING EDITOR, NOT TEAM WRITING	/	2.66	2.55	2.00	2.44
VID2	AUTH. EDITOR FORMATS TEXT FRAMES, QUESTIONS	/	2.72	2.67	2.00	2.66
VID3	AUTH. EDITOR STRUCTURES SEQUENCE OF FRAMES	/	2.67	2.78	2.00	2.55
VID4	AUTH. EDITOR COPIES FRAMES FROM OTHER LESSON	/	2.74	2.25	2.00	2.77
VID5	AUTH. EDITOR HAS USER "HELP" INSTRUCTIONS	/	2.62	2.17	2.00	2.33
VID6	AUTH. ED. HAS "HELPS" FOR WRITING PRACTICES	/	2.72	2.17	2.00	2.77
VIE	USE AUTH. EDITOR FOR OFF-LINE MATERIALS	/	2.71	3.42	4.00	2.62
VIE1	USE AUTH. EDITOR FOR OFF-LINE TESTS	/	2.88	3.67	4.00	2.66
VIE2	USE AUTH. EDITOR FOR OFF-LINE LESSONS	/	3.02	3.25	4.00	2.88
VIE3	AUTH. EDITOR TO REVIEW, REVISE OFF-LINE MATERIALS	/	2.84	3.17	4.00	2.33
VIE4	PRINT MASTER COPY FOR OFF-LINE MATERIALS	/	2.74	2.92	4.00	1.77
VIE5	PRINT MULTIPLE COPIES FOR TRYOUTS	/	2.80	3.00	4.00	3.11
VIE6	CONDUCT ON-LINE TRYOUTS	/	2.86	3.67	4.00	2.55
VIF	USE EDITORS FOR COURSE DOCUMENTATION	/	2.64	3.25	4.00	2.44
VII - INFORMATION RETRIEVAL AND REPORTS ##						
VIIA	REPORTS FOR INSTRUCTORS	/	2.70	2.50	3.00	2.72
VIIA1	LEARNING CENTER ROSTERS	/	3.11	3.00	4.00	3.27
VIIA2	BLOCK PROGRESS REPORTS	/	2.93	2.08	3.00	3.59
VIIA2A	LESSONS STUDENT HAS COMPLETED	/	3.19	2.33	3.00	3.44
VIIA2B	ATTEMPTS AND SCORES ON LESSONS	/	3.02	2.25	3.00	3.66
VIIA2C	OBJECTIVES FAILED IN BLOCK	/	2.92	2.08	3.00	2.77
VIIA2D	TIME ON LESSONS AND ON BLOCK	/	3.10	2.83	4.00	3.77
VIIA2E	TIME AHEAD OR BEHIND SCHEDULE	/	3.10	2.33	3.00	4.00
VIIA2F	HOMEWORK ACCOMPLISHED	/	3.22	2.13	--	3.66

				MEAN RATINGS			
	FUNCTION		/	FTD/OJT	UNT	PT	AU
	VIIA3	STUDENT HISTORY REPORTS	/	2.90	3.33	4.00	3.50
	VIIA3A	ATTITUDE AND INTEREST INFORMATION	/	3.05	4.13	--	2.63
	VIIA3B	SCORES ON ENTRY SKILLS	/	2.81	3.33	4.00	3.29
	VIIA3C	TIMES IN BLOCK REMEDIATION	/	3.14	3.00	3.00	4.33
	VIIA3D	OBJECTIVES FAILED MORE THAN TWICE	/	2.66	2.42	3.00	2.88
	VIIA3E	ABSENCE TIMES AND REASONS, BY BLOCKS	/	3.17	3.00	--	4.11
	VIIA4A	ADDITIONAL REPORT: ABSENCE REPORT	/	3.24	3.58	4.00	4.39
	VIIA4B	ADDITIONAL REPORT: HOMEWORK SUMMARY	/	3.21	3.75	4.00	3.69
	VIIA4C	ADDITIONAL REPORT: ON-LINE DISPLAY, STUDENT DATA	/	3.02	2.50	3.00	2.90
	(VIIB	TRAINING MANAGEMENT REPORTS)					
(S)	VIIB1	REPORT, STUDENT AWAITING TRAINING	/	2.71	3.75	4.00	4.29
(S)	VIIB2	REPORT, STUDENTS BY BLOCK, ROOM, OR BASE	/	2.78	3.25	3.00	4.11
(S)	VIIB3	REPORT, DISTRIBUTION OF BLOCK TIMES	/	3.17	2.88	3.00	4.77
(S)	VIIB4	REPORT, DISTRIBUTION OF COURSE TIMES	/	3.11	2.75	--	4.77
(S)	VIIB5	REPORT, PERFORMANCES BY ROOMS OR BASES	/	3.00	3.13	3.00	3.19
(S)	VIIB6	REPORT, RESOURCE UTILIZATION	/	2.94	2.88	3.00	3.59
(S)	VIIB7	REPORT, INSTRUCTOR UTILIZATION-PERFORMANCE	/	2.70	2.88	3.00	3.50
(S)	VIIB8	REPORT, STUDENT TIMES, GRADES BY BLOCKS	/	2.79	3.00	3.00	2.79
(S)	VIIC	COURSE EVALUATION SUMMARY	/	3.02	2.75	3.00	3.44
(S)	VIIC1	FIRST ATTEMPT TIMES, SCORES	/	3.20	2.88	3.00	3.88
(S)	VIIC2	FINAL TIMES, SCORES	/	3.16	2.63	3.00	2.90
(S)	VIIC3	MEAN, SD, 1ST ATTEMPT TIMES AND SCORES	/	3.35	2.75	3.00	3.69
(S)	VIIC4	MEAN, SD, FINAL LESSON, BLOCK SCORES	/	3.35	2.75	3.00	3.50
(S)	VIIC5	MEAN, SD, 1ST ATTEMPT LESSON, BLOCK TIMES	/	3.38	2.88	3.00	3.88
(S)	VIIC6	MEAN, SD, LESSON, BLOCK COMPLETION TIMES	/	3.29	2.88	3.00	3.77
(S)	VIIC7	SCORE, TIME DATA BY LESSON ALTERNATES	/	3.26	2.88	3.00	4.22
(S)	VIIC8	SCORE DATA BY OBJECTIVES IN LESSONS	/	3.08	2.63	3.00	3.19
(S)	VIIC9	FIRST ATTEMPT LESSON FAIL RATES	/	3.20	2.88	3.00	4.11
(S)	VIIC10	FIRST ATTEMPT OBJECTIVE FAIL RATES	/	3.15	2.75	3.00	3.77
(S)	VIIC11	CORRELATIONS, ACTUAL/PREDICTED TIME, SCORE	/	3.36	2.75	3.00	4.33
(S)	VIIC12	SUMMARY, FAIL RATE ABOVE "X" PERCENT	/	3.13	2.75	3.00	3.25

			MEAN RATINGS		
FUNCTION	/	FTD/OJT	UNT	PT	AU
(S) VIID TEST ITEM EVALUATION REPORT	/	2.97	4.00	--	2.44
(S) VIID1 TIMES EACH ALTERNATIVE IS SELECTED	/	3.08	3.00	3.00	2.11
(S) VIID2 TIMES EACH QUESTION IS ANSWERED CORRECTLY	/	2.99	3.13	3.00	2.22
(S) VIID3 FOR ALTERNATIVES, AVERAGE TEST SCORE	/	3.49	3.00	3.00	2.11
(S) VIID4 FLAG ALTERNATIVES MISSED BY X% OR MORE	/	2.94	2.50	3.00	2.00
(S) VIID5 ITEM REMAINDER CORRELATIONS	/	3.21	2.88	3.00	3.12
(S) VIID6 MEAN, SD, SCORES BY OBJECTIVE AND TEST	/	3.27	2.88	3.00	2.09
(S) VIID7 DISTRIBUTIONS OF SCORES ON TESTS	/	3.05	2.75	3.00	2.63
(S) VIID8 ALPHA RELIABILITIES FOR OBJECTIVES, TESTS	/	3.04	3.00	--	2.66
(S) VIID9 RELIABILITY COEFFICIENT FOR OBJECTIVES, TESTS	/	3.23	2.75	--	2.55
(VIIE CAI EVALUATION DATA)..					
(S) VIIE1 CAI, % SELECTING QUESTION ALTERNATIVES	/	3.20	3.00	3.00	3.00
(S) VIIE2 CAI, % SELECTING BY ATTEMPT NUMBER	/	3.28	3.00	3.00	3.44
(S) VIIE3 CAI, TIMES TO READ AND TO RESPOND	/	3.29	3.13	3.00	3.66
(S) VIIE4 CAI, LIST UNANTICIPATED RESPONSES	/	3.29	3.00	3.00	3.33
(S) VIIE5 CAI, OPEN-ENDED STUDENT COMMENTS	/	3.12	2.88	3.00	3.00
(S) VIIE6 CAI, RECORD STUDENT PATH THROUGH LESSON	/	3.13	2.88	3.00	3.79
(S) VIIE7 CAI, STATISTICS ON MAJOR UNITS OF PROGRAM	/	3.35	2.88	3.00	3.33
(S) VIIF COURSEWARE DEVELOPMENT MANAGEMENT REPORTS	/	3.31	3.25	3.00	3.11
(S) VIIG PERFORMANCE FORECAST REPORTS TO FIELD	/	3.15	2.50	--	4.19
(S) VIIG1 PRE-SERVICE EDUCATION, VOCATIONAL TRAINING	/	3.20	2.50	--	3.79
(S) VIIG2 PRE-SERVICE OCCUPATION, JOB EXPERIENCE	/	3.38	4.00	--	4.09
(S) VIIG3 AF PERSONNEL RECORDS DATA - ASVAB, ETC.	/	3.36	3.75	--	3.89
(S) VIIG4 IN-SERVICE TRAINING PERFORMANCE DATA	/	3.11	3.25	--	4.22
(S) VIIG5 SPECIALTY-RELATED DEFICIENCIES	/	2.90	3.13	3.00	4.33
(S) VIIG6 PREDICT PERFORMANCE IN FIELD ASSIGNMENT	/	3.53	2.75	3.00	4.12
(VIIH SPECIAL PURPOSE REPORTS)..					
(S) VIIH1 SPECIAL REPORTS-BASIC DATA RETRIEVAL, BACKGROUND	/	3.21	2.25	2.00	3.09
(S) VIIH2 SPECIAL REPORTS-INTERACTIVE RETRIEVAL	/	3.07	1.63	1.00	2.79
(S) VIIH3 SPECIAL REPORTS-RETRIEVAL WITH STATISTICS	/	3.47	2.25	2.00	2.72

APPENDIX F

Summary of interview results from Air Force training: Extension Course Institute (ECI); Field Training Detachments (FTD); On-The-Job Training (OJT); Undergraduate Navigator Training (UNT); and Undergraduate Pilot Training (UPT).

An X indicates that a program expressed a need for a particular function. Category 1 functions are already provided by the low-cost system, Category 2 functions require that minor modifications or additions be made to the low-cost system, and Category 3 functions are those which would require considerable modification or addition to the low-cost system.

I - STUDENT TESTING AND EVALUATION (INCLUDING CERTIFICATION AND QUALIFICATION)

SUMMARY: Most of the capabilities mentioned below are already included in the specification for the low-cost CAI/CMI system. Item 14 below would require minor software modification to accommodate coding to STS, Skill Level, and CDC volume. Item 15 requires interface between a wide range of training programs and locations, and should be investigated as the interface between the low-cost system and other AF computer based systems is being defined.

	FUNCTION	ECI	FTD	OJT	UNT	UPT	CATEGORY
1.	On-line test item development and modification	X	X	X	X	X	1
2.	Computerized storage of comprehensive test item banks	X	X	X	X		1
3.	Association of individual identification with training profile and next test	X		X	X		1
4.	Verification of student eligibility for test	X		X	X		1
5.	Computer generation of next required test (including retakes)	X	X		X		1
6.	Test security	X	X	X	X	X	1
7.	Remote, on-line testing capability	X	X	X	X	X	1
8.	Adaptive, branch testing capability	X					1
9.	Rapid student access to required test	X					1
10.	Rapid feedback of test results to student and supervisor	X	X	X	X	X	1
11.	Rapid distribution of test results and training completions	X	X	X	X	X	1
12.	Continuous test item analysis and feedback	X	X	X	X	X	1
13.	Maintenance (storage) of test data	X	X	X	X	X	1

APPENDIX F (CONTINUED)

	FUNCTION	/ ECI	FTD	OJT	UNT	UPT	/CATEGORY
14.	Computerized coding of test items to STS, Skill Level, AFSC and CDC volume	X					2
15.	Computerized elimination of duplicative, generic test items between AFSCs	X					3
	II - STUDENT ASSIGNMENT SUMMARY: Items 3 and 4 below would require minor modification to the low-cost system, and would entail much careful work by training personnel to provide the necessary definitions and classifications so that these capabilities would be based on accurate and complete information.						
1.	Assignment of required training event, module, or volume	X	X	X	X	X	1
2.	Assignment of best available remedial material/resources	X			X		1
3.	Identify available/applicable study material in response to student request	X		X	X	X	2
4.	Preclude duplicative, redundant training	X	X				2
	III - STUDENT PROGRESS MANAGEMENT SUMMARY: Items 1 through 7 are included in the low-cost system. Items 8 through 13 involve interface with other programs or computer based systems, and should be planned as part of that interface.						
1.	Associate individual identification with training profiles	X		X			1
2.	Provide training profile security	X	X	X	X	X	1
3.	Provide individual procedural instructions	X		X			1
4.	Establish individual progress goals/suspenses	X		X			1
5.	Notify of inadequate progress and/or missed suspenses	X		X	X	X	1
6.	Identify remedial needs on basis of test/qualification/certification results	X	X	X	X		1
7.	On-line student sign-in/sign-out (includes flying, simulators, trainers)					X	1
8.	Continual assessment of individual training/education requirements, based on:						
	Civilian education and/or occupation(s)	X				X	3

APPENDIX F (CONTINUED)

FUNCTION	ECI	FTD	OJT	UNT	UPT	CATEGORY
In-service training and/or education	X	X	X	X		3
AFSC, Skill level, and STS	X		X			3
Qualification and certification requirements			X			3
9. Verification of individual eligibility for self-requested training	X					3
10. Verification of individual eligibility for computer-assigned training	X			X	X	3
11. Establish earliest and latest dates for retake of tests	X		X	X		3
12. Establish and notify of qualification/certification suspenses			X			3
13. Prepare local training schedules (interface with host base maintenance schedule, provide weekly academic, simulator and flying schedules which can be adjusted daily for weather or maintenance aborts and test or flight check failures		X		X	X	3
IV - SUPPORT FOR GUIDANCE AND COUNSELING SUMMARY: Minor modification needed to software to provide Item 1 below.						
1. On-line preparation of counseling reports				X		2
V - COMPUTER AIDED INSTRUCTION SUMMARY: Most of the required CAI capabilities are included in the low-cost system. Item 3 would require additional hardware (touch panels or light pens) and some software additions. Movement would require major hardware and software additions--and might best be provided by video tape or disk equipment treated as media devices, rather than as on-line CAI.						
1. Interactive testing (excluding hands-on performance check items)	X		X		X	1
2. Interactive review and remediation	X		X		X	1

APPENDIX F (CONTINUED)

FUNCTION	/ ECI	FTD	OJT	UNT	UPT	/CATEGORY
3. Interactive (on-line) delivery of program (course) material - Programs include Type 1 (Contract Training), Type 2 (Special Resident Training), Type 3 (Regular Resident Training), Type 4 (Field Training, FTD), Type 5 (Other Agency Training), Professional Military Education, On-The-Job Training (OJT), Certification Training, Qualification Training, Requalification Training, and Ancillary Training. Should have touch panel or light pen, Graphics, Movement, Color, and Audio Tape Interface	X		X		X	2

VI - CMI DATA BASE AND CAI MATERIALS PRODUCTION AND UPDATE

SUMMARY: Items 3 through 7 require minor modification to software, after clearly defining what must be accomplished. Item 8 would be a Category 1 item, already provided, except for the "AF-wide distribution"--if distribution is not via computer network, then Item 8 is provided by the low-cost system. Item 9 requires a degree of interface among AF training programs that is outside the scope of the low-cost system.

FUNCTION	/ ECI	FTD	OJT	UNT	UPT	/CATEGORY
1. On-line capability for non-programmer authors to easily:						
a) Enter, store, and change program structure, requirements, and control documents	X	X	X	X	X	1
b) Enter, store, and change program materials	X	X	X	X	X	1
c) Enter, store and change test items	X	X	X	X	X	1
2. On-line student enrollment/registration	X	X	X			1
3. Enter and store program material in an encyclopedic/word order manner	X		X		X	2
4. Modularize generic training material coded for recall and use in multiple courses with similar requirements	X	X	X			2
5. On-line procedures to minimize coordination/approval actions	X	X				2
6. On-line entry, storage, and maintenance of related training/personnel records (e.g., AF Form 623 and SPOTS Master File) and elimination of hard copy maintenance	X	X	X	X	X	2

APPENDIX F (CONTINUED)

	FUNCTION	ECI	FTD	OJT	UNT	UPT	CATEGORY
7.	On-line entry, storage, and maintenance of navigation tasks by weapon system and command				X		2
8.	On-line preparation, maintenance and AF-wide distribution of refresher and/or upgrade training material				X		3
9.	Identification of inter- and intra-program content overlap and redundancy	X	X				3

VII - INFORMATION RETRIEVAL AND REPORTS

SUMMARY: Items 3 through 6 could be provided by the low-cost system, at small expense for software modifications. Item 7 is a capability of the low-cost system, but only at the local level--the interface problems in making this AF-wide would need further definition. Items 8 through 14 would be difficult to incorporate into the low-cost system, because they require systems at the local level to be aware of, and to act on, data at the AF level.

	FUNCTION	ECI	FTD	OJT	UNT	UPT	CATEGORY
1.	Courseware evaluation reports	X	X	X		X	1
2.	Individual training profiles, including preservice training, education, and occupations, in-service training/education, enlistment/classification data, and qualification/certification status	X	X	X	X	X	1
3.	Courseware development status, including projected completion date and OPR, review completion dates and OPRs, and revision suspense dates, status, and OPR	X	X		X	X	2
4.	Test item analysis reports, referenced to STS, JPG, and SPOTS	X	X	X		X	2
5.	Typing of diplomas, graduation certificates, transcripts	X					2
6.	On-line entry, storage, and maintenance of instructor qualifications/status				X		2
7.	On-line preparation and distribution of quarterly production report		X				3

APPENDIX F (CONCLUDED)

	FUNCTION /	ECI	FTD	OJT	UNT	UPT	/CATEGORY
8.	Historical in-service training/education programs data, including programs completed, and completion times, by student type, command, and location	X	X	X	X	X	3
9.	Historical in-service training/education programs data, including Grad Evals by program student type, command, and location	X	X	X	X	X	3
10.	Historical in-service training/education programs data, including resource (facilities, training devices, personnel) utilization by program, command, and location	X	X			X	3
11.	Projected enrollments by program, command, location and student types (includes host base and pipeline - DDA and ABLE GRAD - students)	X	X	X		X	3
12.	Existing enrollments by program, command, location and student types	X	X	X		X	3
13.	Standardization and mobility of program and individual training/education data among related computerized systems (e.g., MMICS and APDS)	X	X	X			3
14.	Cost analysis data including type of program, type/number of student production, resource utilization, command and location	X	X	X		X	3

APPENDIX G

LANGUAGE FEATURES REQUIRED BY THE CAI/CMI FUNCTIONS

Language features were determined by examining the necessary CAI/CMI functional capabilities from Appendix C and determining a set of suggested features for accomplishing those capabilities. The numbers in the "FUNCTIONS" column refer to the Appendix C listing of CAI and CMI functions. The numbers in the "LANGUAGE FEATURES" column refer to the listing of features in Section 5.2.3 of this report.

FUNCTIONS	LANGUAGE FEATURES
All	1, 2, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 17, 20, 21, 22
VA-VC2, VIC3, VIF	3
IA-IVB4, VIA1-VIC, VIF, VIIA1-VIIA4C, VIIB6-VIIB7	9
IB-IB6, VA-VIF, VIIA4C, VIID-VIIE7	16
IA-IIIC6, VIIA1-VIIA4B, VIIB1-VIIB7	18
IB-IB6, VA-VIIA, VIIA4C, VIIB3-VIIB5, VIIB8, VIID-VIID9, VIIH1-VIIH3	19, 23
VA-VC2, VIC3-VIE6	24
VIC4-VIIA2A, VIIB1-VIIB8, VIIF-VIIH3	25
VIE1-VIE4	26

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APPENDIX H

FUNCTIONAL SPECIFICATION
FOR THE
LOW COST CAI/CMI INSTRUCTIONAL SYSTEM

Prepared Under Contract
F33615-78-C-0031

FOR
TECHNICAL TRAINING DIVISION
AIR FORCE HUMAN RESOURCES LABORATORY
AIR FORCE SYSTEMS COMMAND
LOWRY AIR FORCE BASE, COLORADO

BY
MC DONNELL DOUGLAS ASTRONAUTICS COMPANY - ST. LOUIS
ST. LOUIS, MISSOURI 63166

1.0 SCOPE

This specification establishes the requirements for an operationally configured, low cost, computer-managed instruction (CMI)/computer-assisted instruction (CAI) system. The specification includes those CMI and CAI functions identified as having potential payoff from an operational viewpoint, and excludes "nice to have" or "rich" capabilities for support of research and development (R&D) and other non-operational functions.

The system shall be a dedicated local system, rather than a large central system serving more than one Technical Training Center (TTC) or a system made up of several stand-alone mini-systems. A modular approach to expansion shall be incorporated into the design, to facilitate such trade-offs as fewer on-line students in exchange for heavier CAI usage, and to accommodate increasing memory or mass storage in order to handle increased loads.

The system, including the on-line CMI/CAI data base, shall be sized to provide operational CMI/CAI support for at least five hundred (500) students per shift for two shifts. Further design assumptions are: these students are distributed equally across five (5) different courses; each student averages five (5) CMI transactions per shift; not more than 10% of the students will use CAI at any one time; up to nine (9) administrators (instructors or supervisory personnel) can be on-line simultaneously; and batch processing is accomplished off-shift (i.e., during periods of low or no student CAI/CMI load), except for essential recovery of lessons which are stored off-line. The hardware system shall be adequate to provide the functions described in Section 3.0 of this specification while meeting the constraints and assumptions described above.

2.0 APPLICABLE DOCUMENTS

The following documents, of the issue in effect on the date of invitation for bids or request for proposals, form a part of this specification to the extent specified herein. Any reference to the following documents, by basic number only, in other paragraphs herein shall be deemed to apply to the issue current at the time of issuance. In the event of conflict between the documents referenced here and other detail content of Sections 3.0 and 4.0, the detailed requirements of Sections 3.0 and 4.0 shall be applicable.

2.1 GOVERNMENT DOCUMENTS

MILITARY SPECIFICATIONS

MIL-H-46855	Human Engineering Requirements For Military Systems, Equipment and Facilities
MIL-E-6051D	Electromagnetic Compatibility Requirements, Systems
MIL-Q-9585A	Quality Program Requirements
MIL-T-23991	Training Devices, Military: General Specification For

MILITARY STANDARDS

MIL-STD-785A	Reliability Program For Systems and Equipment Development and Production
MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-143B	Standards and Specifications, Order of Precedence For The Selection of
MIL-STD-470	Maintainability Program Requirements (For Systems and Equipments)
MIL-STD-490	Specification Practices
MIL-STD-882	System Safety Program for Systems and Associated Equipment: Requirements for
MIL-STD-1472A	Human Engineering Design Criteria for Military Systems, Equipment, and Facilities

3.0 FUNCTIONAL REQUIREMENTS

This Section describes the functional requirements for the low cost CMI/CAI system.

3.1 STUDENT TESTING AND EVALUATION

The system shall read students' test forms, score tests, provide each student with feedback on test results, and record the results in an on-line data base. The test results shall be made available in printed reports for evaluation and quality control purposes. The system shall support at least the following types of tests: aptitude tests, lesson and block tests, performance checks, and attitude measures. The types of allowable questions shall include at least true-false, multiple choice, and scalar.

The system shall include on-line and off-line testing. The on-line testing shall be supported by interactive terminals. Off-line testing shall be supported by management devices, which shall include optical mark readers, badge readers, off-line response devices, or other appropriate devices to acquire input from students and instructors; printers to produce hard copies of student status reports*; and other devices as appropriate.

3.1.1 Test Scoring and Feedback Capabilities

The system shall score those tests for which test keys have been entered into the data base (see Section 3.6). The results from tests shall be available in printed format for both the student and instructor. If the test is a pass/fail test, training managers shall be able to specify the pass/fail criteria. The criteria shall include at least the following:

- Answers can be scored either right or wrong, and a designated percent correct can be required to pass the test.
- Objectives can be defined within the test and a subset of the test questions can be identified as relating to each specified objective. It shall be possible to use a question for more than one objective.
- Any objective can be designated as a critical objective and the test will be failed if the objective is failed.
- A subset of objectives can be defined, with a minimum number of objectives from the subset required to be passed in order to pass

* A status report shall be printed as part of each student CMI transaction. Each status report shall include appropriate feedback to the student on the lesson or other assignment just completed, and shall include appropriate direction as to the student's next action--lesson assignment, test assignment, etc.

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the test. For example, five objectives on a ten-objective test can be specified as a subset, and the system can require that three or more of these objectives must be passed or the test will be failed.

Test keys and other information required to score tests shall be entered at an interactive terminal.

The system shall score performance checklists completed by instructors. Instructors shall be able to certify that a student has either passed or failed any of the tests, including performance checks, from an interactive terminal or by entering appropriate information via a management device.

3.1.2 On-Line Testing Capabilities

The system shall provide the capability for on-line testing via an interactive computer terminal. For on-line testing, the order of questions and the sequence of alternate answers for each question can be scrambled automatically for each test administration. The order of the alternatives shall be either fixed or random as specified by the author*. The author shall be able to make the extent of testing dependent on the student's responses to earlier questions in the test. A hard copy of the results of on-line tests shall be available from a management device on request. Responses to on-line student test inputs shall be in a real time mode. The time lapse from transmission of student input to start of displaying feedback shall not exceed three (3) seconds in more than 10% of the cases. The time lapse from beginning to completion of the response shall not average greater than twelve (12) seconds.

3.1.3 Determination of Pre-Course Student Characteristics

The system shall provide for storage and retrieval of student characteristics data collected before or at the beginning of training. It shall be possible to use the student characteristics data in examining eliminations as a function of aptitude and of years and types of preservice schooling, and in predicting individual rates of progress toward course completion. The individual characteristics information shall be stored in the on-line CMI data base and shall be available to the CMI system as long as the individual is enrolled in the course.

The system shall be capable of storing and retrieving the following pre-course data for all students enrolled in courses operating with this system:

*NOTE: Within the context of this specification, "author" is used as a generic term to describe Air Force personnel--supervisors, managers, administrators, instructors--involved with operating this system and, in particular, with entering data into the system.

- Relevant Air Force personnel data (e.g., ASVAB or AFQT scores, and such biographical data as previous service training and duty assignments);

- Knowledge of the course material based on criterion referenced pre-tests or other pre-course measures of knowledge/proficiency on training objectives;

- Learning process skills (ability, attitude, or interest measures such as reading comprehension and study habits); and

- Course-specific critical entry skills (aptitudes, abilities, and interests that are specifically related to success in a particular training specialty, such as mathematical ability or interest in the career field).

3.1.4 Determination of Within-Course Student Attitudes and Interests

The system shall make provision for tests to measure the attitudes and interests of students. Pre-course, within-course, and post-course tests of attitudes and interests shall be accommodated. The results of the tests shall be stored in the on-line CMI data base for use in determining training assignments, evaluating instructional materials and procedures, predicting completion times and rates of progress, and predicting performance, as specified by training managers.

3.2 STUDENT ASSIGNMENT

The system shall assign students individually to lessons, tests, and other instructional alternatives. The system shall be structured to allow the training manager to specify what combination of data on lesson characteristics, resource availability, student characteristics, and student performance will be used in determining the assignments of individual students to training alternatives.

A student shall receive the next individual assignment immediately after completing the preceding lesson. Training resources shall be scheduled by the computer system to attempt to maximize throughput. The computer shall track student progress through the lessons and alternatives in the various course versions. The system shall provide reports that can, as desired, replace manual tracking of student progress by instructors.

3.2.1 Assignment to Alternative Course Versions

The system shall support course versions which differ as to content (e.g., for different shredouts of a specialty, or for testing and implementing new training materials). A student enrolled in a particular course version shall be assigned only the training materials for that version. The form or procedure used to register a student in a course shall provide for identifying the student's course and version.

3.2.2 Determination of the Order of Assignments

The system shall have the capability to determine and assign the next lesson alternative for an individual student in all modes except block remediation. The instructor shall not be required to manually track student progress, or to determine assignments to training alternatives, and shall have capability to perform manual override of any assignment. Based on data in the CMI/CAI data base and subject to options selected by authors or data base managers, the system shall be capable of using at least the following information in determining a trainee's next assignment:

- The assignments completed by the trainee to date;
- The performance of the trainee on previous assignments (times and test results on previous assignments);
- The availability of the resources required for existing and allowable lesson alternatives; and
- The current distribution of students, the numbers of students required for any team tasks, and how best to assemble teams of trainees for team tasks.

3.2.3 Assignment to Alternatives Within Lessons

The system shall make individual student assignments to alternatives within a lesson. These can include alternate media (e.g., printed vs. audio-visual) or different instructional approaches (e.g., easy vs. difficult). The assignments can be based on at least the following considerations:

- Availability of the particular media or lesson;
- Prior test scores, times-to-complete, or other within-course data;
- The student's pre-course characteristics (e.g., general aptitudes, abilities, attitudes, interests, or other pre-course data);
- Simple "if...then" logical rules which may be used to select alternatives; and
- Predicted student performance.

Student characteristics and past performance can be used to predict student performance. The student shall be assigned to the media or lesson predicted to result in the best student performance. The system shall accommodate at least two assignment rules for each lesson--best predicted time and best predicted score--which can be specified at the lesson level by an author. If the score rule is selected, the student shall be assigned to the treatment with the highest predicted score. If the time rule is used, the system shall assign the student to the treatment with the shortest predicted time. If the time rule is specified and the student is predicted to fail all of the treatments, the system will use the score rule. These rules will be used only for a student's first attempt on a lesson. Subsequent assignments shall be made using remediation rules (Section 3.2.4). Additionally, resource availability and system throughput constraints shall override the time and the score rules.

The system shall support random assignment of a specifiable percentage of the students to the treatments within a lesson. If 15% random assignment is specified, then a randomly selected 15% of the students shall be assigned randomly to the available instructional alternatives for that lesson. The random assignment function will be used in collecting data to establish assignment rules and to verify the effectiveness of such rules.

3.2.4 Assignment to Alternative Remediation Activities

The system shall make assignments to the available alternate remediation materials and media. At least three categories of remediation shall be supported:

- Lesson Remediation - The system shall support alternatives for use in remediation only. The system shall assign a student to the "best" available remediation alternative for second and subsequent lesson attempts, with "best" defined to be the one alternative chosen from available alternatives based on the considerations listed in Section 3.2.3.
- Lesson Group Remediation - The system shall assign the best available remediation alternatives within a related group of lessons.
- Block or Course Level Remediation - The system shall assign the best available remediation alternatives for the objectives that the student is having difficulty mastering within the block or course.

The alternate remedial selections shall be accomplished by the computer. It shall be possible for instructors to override system decisions via management devices and from interactive terminals.

3.2.5 Test Selection and Assignment

The system shall provide the capability of assigning students to tests. For each student at each testing point, the system shall assign an on-line (CAI) or an off-line (paper and pencil or performance) test, as available and appropriate. If more than one version of a test is available, the alternates shall be assigned randomly. Any versions already attempted by the student shall be excluded on subsequent attempts. Capability shall be provided for manual override of any test assignment by an instructor. On-line programs shall provide the necessary data entry capabilities for implementing this function.

3.2.6 Assignment to Supplementary Skill Training at Course Entry

The system shall be capable of identifying those students with deficiencies in critical entry skills or in learning skill areas and of assigning students to supplementary or remedial skill training. The system shall identify such students based on critiera established by course managers for performance on aptitude, ability, interest, or other precourse or within course measures. Supplementary/remedial training lessons shall subsequently be assigned to students in accordance with hierarchy and resource availability constraints established in the CMI/CAI data base by course managers.

3.2.7 Additional Resource Management Considerations

Based on information entered into the CAI/CMI data base, the system shall track which resources are required for each lesson, if they are available, and where they are located. Managed resources can include classroom spaces, lesson materials, media devices, work stations, simulators, and other training equipment. The system shall be able to assign and direct students to training resources outside of their assigned learning centers, to allow effective sharing of resources by students in several learning centers.

The system shall assign students in a manner that will (1) tend to distribute students evenly throughout the course, (2) attempt to keep as many assignment options as possible open for the students, and (3) make efficient use of available resources. Students shall be assigned to the learning centers with the highest percentages of available space, and shall be assigned to blocks in such a manner as to optimize the distribution of students across learning centers. In the process, the system shall consider team assembly, desired loadings within blocks, and the capacities of learning centers. These considerations shall not, however, override the hierarchical constraints or priority given to each block.

The computer system shall base the above management decisions on data entered into the on-line data base. Once a course version is operative, training management personnel shall be required to enter only course changes as they occur. These include changes in the course structure (e.g., lessons added or removed, or the prerequisite order of assignment changed), and resource availability (e.g., new equipment added, and equipment removed, inoperative or in maintenance). The changes shall be entered using on-line programs and shall take effect when entered.

3.3 STUDENT PROGRESS MANAGEMENT

The system shall support management of a trainee's progress through a self-paced individualized training course. These capabilities shall range from lesson scheduling to progress prediction and management. Both the student and the instructor can be informed, at any time, as to the student's progress--ahead of, behind, or on schedule.

3.3.1 Scheduling Student Entries Into The Course

At the end of each training day, the system shall identify the number of vacancies in each course operating under the system. This information will allow the student squadron or other administrative authority to effectively plan and program course entries and minimize student delay awaiting training.

3.3.2 Graduation Forecasting

The system shall, as part of the student monitoring and management process (Section 3.3.3), predict the date on which a student will complete the course. Learning center rosters shall be available on request, and shall identify students and their predicted graduation dates during the date/time interval specified in the training manager's request. The rosters shall be available in printed form, and for display at an interactive terminal. The average response time, from submission of a request to completing printout of a roster, shall not exceed two (2) seconds per student. The system shall also, on request, generate graduation reports for the local training center personnel office. These reports shall be generated on the central site line printer.

The system shall be configured to facilitate interface directly with the training center personnel management computer system. To implement this function, the Air Force will specify the format of the data and the medium in which the training center personnel computer will receive the required information. Any required changes to the training center personnel computer software will be accomplished by Air Force personnel.

3.3.3 Monitoring and Management of Student Progress to a Target

The system shall determine a target progress rate for each student. The rate for a student shall be used to generate a targeted time for completion of the course and for completion of individual blocks. The target progress rate for a student shall be based on pre-course data and on available within-course performance data. The targets shall be relative to average completion times for blocks and course. A student's target completion date shall be calculated based on the target progress rate, expected shift length, predicted days the student will be in class, the student's performance record, and the percentage of the course remaining. Each student shall have access to his/her target time to complete for each block. Both the student and the instructor shall receive feedback on the student's actual progress rate relative to targeted progress rate. The student shall be given information, on the first status report of each training day, that will let the student determine how actual progress to date compares with predicted progress.

3.4 SUPPORT FOR GUIDANCE AND COUNSELING

The system shall provide computer generated reports to support student guidance and counseling by instructors and course management personnel. If the necessary tests are included in the pre-course assessment, the reports shall identify entry skill deficiencies as well as deficiencies in within-course performance. The instructors will determine which students are to receive counseling, and can retrieve from the computer both the background characteristics and within-course performance information needed to support their guidance and counseling activities.

3.4.1 Identification of Students Needing Special Attention at Course Entry

The system shall identify students predicted to be proficient or deficient with respect to mastery of course or training objectives specified by course personnel. This identification and reporting is initiated at the beginning of the training process to focus instructor/management attention toward students most in need of special training procedures, guidance, and counseling.

The identification process shall produce computer generated lists of those students measured as being either proficient or deficient on the basis of their pre-course assessments. This initial listing shall report, by student, individual scores on the pre-course critical entry skill variables (e.g., reading, math, or study skills). A second report shall provide individual scores for all students on those variables identified as critical entry skills, and shall also flag deficient students and their related scores. These reports shall be available for display at the interactive terminals.

3.4.2 Identification of Marginal Student Performance

The system shall produce reports identifying and reporting students predicted to have difficulty mastering further training objectives based on recorded within-course performance. The reports shall be available on demand and utilized to direct timely remedial/counseling assistance to students most in need. The system shall be capable of assigning those students identified as marginal to specialized remedial training (e.g., to special instructor tutorials, remediation sessions, or special skill training for correcting learning or study skill weaknesses).

The system-generated reports shall include a list of those students not meeting predetermined limits of satisfactory predicted progress rates, or scoring below the training manager's criterion levels for training objectives. They shall include actual time and score data. The students below the course-established minimums for acceptable performance will he flagged as possible candidates for elimination or other established administrative action.

3.5 COMPUTER-AIDED INSTRUCTION (CAI)

Lesson materials can be entered into, stored in, and retrieved and delivered by the computer system. When assigned by the system and requested by the student, they can be displayed at an interactive terminal. The lesson materials can include text, questions, graphics, and special purpose programs. Student interactions can range from a simple "turning the pages" type of program through very sophisticated interactive exchanges via special purpose programs. Student interactions are principally via a terminal keyboard and, if appropriate, via a touch panel, light pen, or other device.

3.5.1 CAI Applications

The CAI provided by this system shall support at least the following five CAI functions for use in Air Force resident technical training:

- Drill and Practice, with correction and guidance, of basic skills and knowledges learned via other media;
- Tutorial--use of CAI for lessons which are particularly difficult;
- Simulation--use of special purpose programs to simulate equipment operation or maintenance processes;
- Review and Remediation--use of CAI to quickly review the content of a block prior to a block test or to remediate failed objectives following a block test failure; and
- Study Skills--use of CAI to teach specific study skills to students who are deficient in these areas.

3.5.2 CAI Capabilities

A CAI lesson shall consist of a series of frames, or equivalent means of storing and presenting information. The system shall support at least the following types of frames, or their equivalents: text frames that can contain at least 4 pages of information (a page can contain at least 21 lines); question frames; and documentation frames which the student cannot access. The documentation frames are reserved for course authors to record development status data. The system shall provide for at least 100 objectives per lesson and 100 frames per objective.

The system shall support CAI lessons of varying levels of sophistication. The basic CAI lesson will consist of text presentation, and will allow response to multiple-choice and true-false questions via a typewriter-like keyboard. The system shall be able to provide feedback messages specific to the individual student's responses and number of attempts on the current objective. The system shall also allow branching to any available frame addressing the current objective, or to the first frame of any other objective within the lesson. The lesson progression shall be adaptable to the student's responses. The branching selection shall allow branching to any available frame addressing the current objective or to the first frame of any other objective within the lesson. The lesson progression shall be adaptable to the student's responses. The branching selection shall be based on the student's prior responses/performance within the lesson.

For more sophisticated CAI lessons, the system shall support graphics presentations, color displays, student entry of constructed responses (open-ended English answers), control of supplementary slide or filmstrip presentations, control of audio tapes, and adaptations based on the CMI on-line data base (e.g., ASVAB or AFQT scores, pre-course assessments, and within-course performance data). The system shall support the audio tape player and the projector via an external computer-controlled jack on the interactive terminal. To facilitate student interactions in these CAI lessons, the system shall support the usual keyboard inputs and shall also support an additional device such as a light pen or touch panel. To facilitate preparation of graphic displays, the system shall support a digitizing tablet or equivalent device.

The system shall have the capacity for on-line mass storage of a minimum of 150 lessons, available for immediate access. The lessons are assumed to average three objectives per lesson, 60 frames (or equivalent) per objective, 2 pages per frame, and 15 lines per page (average line length, 60 characters). Lessons in daily use shall be available on the system at all times, with no more than a ten (10) second delay in initiating student access. When a student has indicated completion of a frame, the average time for the system to determine and initiate the next display shall not exceed three (3) seconds. The average time to complete the display shall not exceed twelve (12) seconds.

Inactive lessons which are stored off-line shall be recoverable for normal on-line accessibility not later than the start of the next training day following the request for restoration.

3.5.3 On-line Learning Process/Specialized Skill Training

The CAI system shall support presentation, to either students or instructors, of specialized training in interactive formats. This training may include, for example, materials designed to teach study habits and skills, test taking skills, and memorization skills to students, or to teach diagnostic, tutorial, authoring or counseling skills to instructors.

3.6 CMI DATA BASE AND CAI MATERIALS PRODUCTION AND MAINTENANCE

To effectively perform CAI/CMI training functions, the system must be informed as to the trainees (name, social security number, course, etc.), the course structure (tests, lessons, resources, allowable sequences of lessons, etc.), and student performance (lessons completed, test scores within the current block, block completion times, etc.). In the case of CAI, all of the lesson information (text, questions, graphics, branching instructions, etc.) must be stored within the computer system. The following paragraphs describe the requirements for entering, storing, and maintaining these types of information.

3.6.1 CMI Course Definition Data Base

The system shall provide the capabilities which will allow training managers to enter the course structure into the system. The program(s) shall run on-line--i.e., a training manager shall be able to use an interactive terminal to directly enter, store, display, and change course related information. To facilitate use, the on-line system shall use graphics to display the course structure (i.e., the allowable paths through the lesson materials), and there shall be an on-line capability to access each file in the CAI/CMI data base. Additionally, it shall not be necessary for authors to be familiar with any programming language in order to use these capabilities effectively.

3.6.2 Automatic Validation of Course Data Base Integrity

Before a new course or course version is implemented, necessary information/description relative to all of the blocks, lessons, courseware, and tests in the course must be entered into the data base. The system shall include one or more computer programs for determining if all required data base records defining the course are present and consistent. The program(s) shall be designed to facilitate use by authors and shall not require knowledge of a programming language. To the greatest extent possible, the program(s) shall update the on-line data base, if this capability is enabled by the training manager. The program(s) shall run in not more than fifteen (15) minutes in validating the data base for a course.

3.6.3 Production of On-Line Tests

The CAI system shall include the capability for on-line testing. This shall be implemented via an on-line test item editor, or equivalent capability, for entering test questions, their alternatives, and the necessary control information. This capability shall allow the author to enter test items by typing text at an interactive terminal, and shall also format the questions for the author and allow the author to decide whether or not to (a) randomize the presentation order of the test items and the alternatives within test items, (b) control the number of attempts the student can make on each item, and (c) enter student feedback messages to follow either correct or incorrect answers.

3.6.4 CAI Authoring

The system shall provide an on-line CAI authoring editor, or equivalent capability, which shall assist in structuring the authoring tasks. This capability shall provide standardized formats for text and question frames, and shall provide the capability to copy or share text frames, questions, and graphics between lessons. A users manual shall be provided for the CAI production process. Additional instruction shall be displayable during the authoring process via a HELP request. The HELP information shall include operating instructions for the program, plus guidelines for preferred instructional practices. This capability shall be simple enough that an author without prior programming experience can learn to use it in not more than two weeks. An author shall have access to any frame in any lesson that is allowable within system security constraints. Students shall not be able to access lessons in the author mode. Additionally, the program(s) shall provide capability to readily change any of the course materials stored in the on-line data base.

3.6.5 Production of Off-Line Materials

It shall be possible to use the system in producing tests and instructional materials which are intended for use off-line (e.g., programmed texts). Programs shall be designed for use in writing, reviewing, and revising the tests and instructional materials and for printing the final product in a format ready for reproduction. It shall be possible to print a limited number of copies in order to facilitate early reviews and small group tryouts. This system capability shall also facilitate conducting small group tryouts on-line, and shall be useable for acquiring information on the students' reactions to instructional materials.

3.6.6. Production and Maintenance of Course Documents

An interactive capability similar to that provided for test items and CAI authoring shall be provided for developing, storing, maintaining, and retrieving course documentation such as Plans Of Instruction (POIs), course charts, and lesson outlines. These documents shall be available at any time for review or revision, and limited numbers of copies can be printed as needed.

3.7 INFORMATION RETRIEVAL AND REPORTS

Information relative to the trainees, courses, course materials, tests, test items, and other components of the system shall be stored, and available for periodic (hourly, daily, weekly, monthly...) analyses and reports. These functions are intended principally to support instructors, managers, and administrators. They can be valuable to instructors involved with course management and student guidance. They can also be valuable in providing an effective quality control mechanism for improving the management and administration of training, and evaluating and improving the process of training program development and implementation. A report requested at a terminal shall be provided to the requester only if security requirements for access to the requested information are satisfied.

3.7.1 Reports for Instructors

Data shall be collected, stored, and made available in reports structured to meet instructor needs. The reports shall include but not necessarily be limited to the following: student rosters, individual block progress reports, individual biographical reports, and absence summaries for learning centers. They shall be available via either the interactive terminals or in printed form. The instructor shall also have access via the terminals to all other student data not included in the above routine reports, but subject to established security constraints.

3.7.1.1 Learning Center or Classroom Rosters. The system shall provide, on request, via either an interactive terminal or in printed form, at least four types of rosters: resource, assignment, time management, and homework. The rosters shall include social security numbers and names for the students included on the list. The resource roster will list those students in the learning center who have resources assigned to them, the types of resources, and the learning centers to which the resources are assigned. The assignment roster will list the current training activity assignment for each student by learning center. The time management roster will include carrel (or position) number, absence status, current block, and rate of progress for individual students by learning center. The homework roster will identify the amount of the course completed to date and the proportion completed through voluntary homework for individual students by learning center. After the terminal has transmitted a roster request to the central site computer, the average processing time per student shall not exceed one (1) second.

3.7.1.2 Individual Block Progress Reports. The individual block progress report will summarize student progress for the block specified. The information in the block progress report shall include at least the following:

- Lessons completed in the block;

- Numbers of attempts, and scores on each attempt, for each lesson and test;
- Objectives failed on each test; and
- Time spent on each attempt and total time spent in the block.

3.7.1.3 Individual Student History Reports. The individual student history report will include the student's scores on pre-course aptitude and interest measures, scores on any critical entry skill tests, time spent in remediation following a block failure, and any lesson objectives that were failed more than twice.

3.7.1.4 Absence Summary. The absence summary shall be a block-by-block summary of the absences reported to the system and shall be capable of replacing manual absentee reporting. It shall indicate when the student was reported absent, when the student returned, how long the absences lasted, and the reasons for the absences.

3.7.1.5 On-Line Display of Student Data. Capabilities shall be provided for retrieval and display of available student information in response to requests which meet security requirements.

3.7.2 Training Management Reports

The following information, intended for use by training managers (shift supervisors and above), shall be provided in the form of standard reports available on request to authorized users:

- Students awaiting training, by course;
- Numbers of students in training by course, learning center, and Technical Training Center;
- Distributions of completion times for individual blocks;
- Distributions of course completion times;
- Differences in student performance between parallel learning centers* or Technical Training Centers;
- Instructional resource (e.g., facilities and training devices) utilization;
- Utilization and qualifications of instructors;

* Learning centers are "parallel" if the same course content is taught in the centers, and are not parallel if the centers teach different content.

- Summary reports of student completion times and final grades, by block and course; and
- Summary reports of disenrollment and elimination data.

3.7.3 Course Evaluation Summary

The system shall include a Course Evaluation Summary (CES) which summarizes student performance on individual lessons within blocks and for entire blocks. It is intended for use in monitoring and evaluating small-group tryouts of new materials as well as student performance on established materials. The CES shall contain at least the following items of information:

- First-attempt lesson and block test socres;
- Final lesson and block test scores;
- Means and standard deviations of first-attempt lesson and block test scores;
- Means and standard deviations of final lesson and block test scores;
- Means and standard deviations of first-attempt lesson and block times;
- Means and standard deviations of lesson and block completion times;
- Separate score and time data for alternative modules within lessons;
- Score data by objective within lessons;
- First-attempt lesson failure rates;
- First-attempt objective failure rates;
- Correlations indicating the relationship between predicted and actual lesson and block times and scores; and
- Summarized data on lessons, modules and objectives with first-attempt failure rates above a specifiable percentage.

The CES shall be a batch mode report. An on-line program shall be provided, however, for submitting requests for the CES for off-shift processing.

3.7.4 Test Item Evaluation Report

The system shall provide a Test Item Evaluation (TIE) report that provides detailed information on the characteristics of block and lesson tests. The TIE is intended to support evaluations of test reliability and validity. The TIE shall include at least the following items of information:

- The numbers (or percentages) of students selecting each alternative answer to test questions;
- Percentages of students answering questions correctly;
- Average test score of students answering each question correctly;
- Flagging test questions missed by over 70 percent or by none of the students;
- Item-remainder correlations for each question;
- Means and standard deviations of scores for each objective and for each full test;
- Distribution of scores on the full test;
- Alpha reliability coefficients for each objective and for the full test; and
- Criterion-referenced reliability coefficients for each objective and for the full test.

The TIE shall be a batch mode report. An on-line program shall be provided to submit the report requests for off-shift processing.

3.7.5 CAI Evaluation Data

Detailed quality control and evaluation data shall be collected by the CAI system. This information shall include at least the following items:

- Percentages of students selecting each alternative on each question, by attempt number (first attempt, second attempt, etc.);
- The means and standard deviations of times to respond to questions and times to read text passages;
- Lists of unanticipated responses to constructed response questions;
- Lists of open-ended student comments regarding the CAI lessons;

- Detailed records of students' paths through CAI lessons; and
- Summary statistics on major units of CAI lessons, such as times to complete and cumulative scores.

This information from CAI lessons shall be available to authorized requesters in batch mode reports. An on-line program shall be provided to submit requests for off-shift processing of these reports

3.7.6 Course Development Management Reports

The program or programs provided for use in developing on-line and off-line tests and materials shall also capture and store information regarding an author's work using the editors, and the status of the associated course material development effort. This information shall be summarized in management reports for monitoring courseware development, production, review, revision, and implementation. The reports shall include such information as identification of the author responsible for developing, reviewing or revising a lesson, how much time has been expended on a particular task, how much of the task has been completed, and the expected (i.e., scheduled) completion date.

3.7.7 Performance Forecast Reporting

The system shall include a report which describes a student's performance levels in completed technical training. This information is intended principally for a student's supervisor in a post-training duty assignment, and for Field Training Detachment (FTD) or On-the-Job-Training (OJT) managers who need reports of individual student performances (e.g., scores and times to complete) in resident technical training or other in-service training.

3.7.8 Special Purpose Reports

Because standard reports will not always satisfy all management and administration requirements, the system shall include an open-ended information retrieval system that can be used to answer ad hoc queries regarding students, materials, and training effectiveness. The user shall be able to specify the variables which he wishes to examine, e.g., types of students or courses by specified time periods. The output shall consist of the number of pertinent cases identified and the mean, standard deviation, and range for each included variable. This basic data retrieval program shall also be interfaced to one of the standard packages of statistical programs such as the Statistical Package For The Social Sciences (SPSS) or the BMD Biomedical Computer Programs, to permit extensive analysis of student data. This data retrieval/analysis capability shall be a batch mode function. An on-line program shall be provided, however, for submitting requests for off-shift processing.

4.0 HARDWARE REQUIREMENTS

A computer hardware system shall be provided to support the instructional, administrative, and management functions required by Section 3.0 of this specification. The system shall consist of commercially available equipment with the capability for handling the types and numbers of jobs specified in Section 3.0. The hardware components provided for this system shall meet the general intent of Military Specification MIL-H-46855, Military Standard MIL-STD-785A, and of the other documents listed in Section 2.0.

The computer system shall provide a capability for modular buildup to the terminal configuration necessary to meet the functional requirements and assumptions in Section 3.0 of this specification. The system shall operate on-line for two eight-hour shifts, five days per week. Batch operations will be carried out during the remaining hours or during weekends.

4.1 MAINFRAME AND PERIPHERALS

The central computer system (i.e., mainframe and peripherals including any communications network processing unit) shall be clustered and housed in a room as centrally located among classroom buildings as is practical. This room shall be a central point for printing CMI records and administrative reports and for performing software maintenance.

The central system shall represent the minimum configuration consistent with meeting the requirements of this specification. High speed communication between two or more processors of the same make and model shall be possible, to allow for future expansions that might require multiple central processors. Consideration shall be given to selecting a computer that does not require such special environmental conditions as chilled water and humdification. Sufficient air conditioning and a raised floor shall be installed with the system.

4.1.1 Central Processor

The processor shall be capable of simultaneously supporting at least the number of student, management, and administrative terminals or other devices needed to meet the functional requirements of Section 3.0 above. To support routine software operations, simple on-line source program editing operations such as line insertions, deletions, and replacements shall be accomplished in an average response time of not more than one (1) second, and more complex on-line operations such as file I/O shall be accomplished in an average response time of not more than three (3) seconds.

An instruction set supporting at least integer and floating point arithmetic, string, character addressing, branching, logical, looping, and assignment operations shall be provided. Instructions or groups of instructions shall also be available to implement array subscripting and record addressing.

At least the following peripheral devices shall be attachable to the central processor: high speed mass storage devices, off-line storage devices (e.g., tape drives), line printers, and an operator console. It shall be possible to add central memory expansion units to the processor without degrading the services offered by the operational system.

A capability for validating data following transfers shall exist, to insure that transfers are successfully and correctly accomplished.

The processor shall be capable of supporting batch processing, but not necessarily while supporting on-line CAI and CMI operation.

4.1.2 Central Memory

Sufficient central memory shall be provided to support the terminals and produce the response times dictated by the functional requirements of Section 3.0 above and by Section 4.1.1. Any type of central memory (e.g., core, MOS, bipolar) shall be acceptable, provided the required response times and validation requirements are satisfied.

4.1.3 Mass Storage

Mass storage shall be provided to support the instructional programs and data required by Section 3.0, and the system programs and data. There shall be at least two mass storage devices, to provide backup in the event one device malfunctions. The mass storage transfer rate plus overhead shall be sufficient to accomplish the required response times.

Channels attached to the mass storage devices shall be capable of accomplishing input/output (I/O) transfers at sufficient rates to fulfill the response time requirements of Sections 3.0 and 4.1.1.

4.1.4 Off-line Storage

Off-line storage shall be provided to support the functional requirements of Section 3.0. For backup and reliability purposes, this storage shall be accessible via at least two off-line storage devices.

The off-line units shall be accessible for backing up information from on-line storage devices and for recovering information which has been temporarily stored off-line to lessen the on-line mass storage requirements. Off-line storage shall be sufficiently accessible to fulfill the requirements for recovering archived CAI lessons (Section 3.5.2 above).

4.1.5 Central Site Printing

Capability shall be provided for printing such information as classroom rosters, course evaluation summaries, test item evaluation summaries, selected student information, CAI reports, on-line and off-line course materials, software programs, and computer maintenance information. One or more central site line printers capable of printing the 128-character ASCII set shall be provided. With an even distribution of all characters, a minimum rate of 500 lines/minute (128 characters per line) is required.

4.1.6 Computer Monitoring

A method and equipment shall be provided to furnish computer status and peripheral device information, initiate diagnostics, and generally monitor and control the operation of the entire system.

4.2 COMMUNICATION SYSTEM

Communication hardware and software sufficient to allow remote or local operation of the terminal system specified in Section 4.3 below shall be provided. Standard protocols, electrical interfaces, and data rates shall be used throughout. This communication system shall be capable of supporting the mix of terminal capabilities specified in Section 4.3 and the response requirements of Section 3.0 of this specification. The communication system shall be modularly expandable beyond the minimum number of terminals required in this specification even though the software and hardware system is initially configured for that number of terminals.

4.2.1 Computer/Network Interface

The network processing hardware at the computer site shall be able to transmit data to and receive data from the total number of terminals required by this specification, and the electronics shall be modularly expandable to handle additional terminals.

The computer electronic ports for system terminals shall meet industry-wide standard interfacing requirements. The network processing equipment shall have the capability of detecting and correcting transfer errors on characters and control codes received from the terminals.

For transmitting data between the computer and terminals at locations remote from the central site, the most cost effective method shall be provided.

4.2.2 Network

The network shall consist of dedicated voice grade lines, configured to provide the data rates needed to satisfy the functional requirements of this specification.

4.3 TERMINAL SYSTEM

The terminal system shall be composed of a mix of types of terminals and other devices that includes:

(1) alphanumeric, graphics, and color display types of terminals for students and administrative use; and

(2) management I/O devices to provide the required CMI functional capabilities.

This compatible set of devices shall be located in or near classrooms, and shall be capable of remote operation with the central computer.

4.3.1 General Characteristics

All display terminals selected shall have the electronic, display, and keyboard characteristics as listed in Sections 4.3.1.1, 4.3.1.2., and 4.3.1.3 below. Management devices shall conform to Section 4.3.1.1.

4.3.1.1 Electronic Characteristics. Each terminal shall be capable of sending and receiving data at selectable industry-standard rates. Transmission shall be via an industry-standard interface. Terminals or associated communications equipment shall have at least the capability of detecting validation errors on single incoming alphanumeric and control characters, with all control codes and character codes conforming to industry standards. Any terminal shall be electronically interchangeable with any other at any communications port.

4.3.1.2 Display Characteristics. Each display terminal shall provide at least 24 lines of display, with 64 characters or more per line, on a screen of at least 12 inches diagonal measurement. The 96 character ASCII set, consisting of upper and lower case alphabet, numbers, and punctuation shall be available. The cursor shall be controllable so that it can be located to any position on the screen. Bulk erase capability shall be provided.

4.3.1.3 Keyboard Characteristics. The keyboard on each display terminal shall be in the standard QWERTY format for alphabetic characters, with numbers and punctuation keys also available. All keys must be plainly and permanently marked to identify characters and/or functions controlled.

4.3.2 Student and Administrative Terminals

A mix of alphanumeric-only, alphanumeric/graphics, and alphanumeric/graphics/color terminals shall be provided for student and administrative use. The numbers of terminals of the various types shall be sufficient to provide the functional capabilities described in Section 3.0, and shall meet any additional requirements imposed by characteristics of the Air Force-designated courses to be implemented on the system. An external jack for controlling a device such as a slide projector shall be provided, if course characteristics indicate that such a device is instructionally desirable. The resolution provided by graphics terminals shall be sufficient to accommodate the course materials to be implemented. Color terminals shall provide at least eight different colors, including black and white, with color available for foreground letters and figures and for background. An option to fill colors within graphics polygon boundaries is desirable. In addition to the keyboards provided for student and instructor interactions, the system shall also support a device such as a light pen or touch panel, to facilitate interaction with graphics displays. To facilitate preparation of graphics displays, the system shall support a digitizing tablet or equivalent device.

4.3.3 Management Devices

Management devices in types and numbers sufficient to satisfy the CMI requirements described in Section 3.0 shall be provided. As necessary to meet the instructional and administrative needs, these shall include devices to read forms, to print student assignments and classroom operations reports (such as rosters, absence reports, and registration data), and such other devices as may be required and cost effective for the designated installation site.

4.4 RELIABILITY

An effective reliability program shall be established and maintained, within the general intent of MIL-STD-785A. This program shall include failure reporting and design changes to correct pattern failures. The program shall be adjusted to suit the types of procurement and equipment, and shall be directed toward maximizing the mean time between failures (MTBF) for individual equipment items. System reliability shall be sufficient to meet the availability requirements of Section 4.6.

4.5 MAINTAINABILITY

A maintainability program shall be established, within the general intent of MIL-STD-470. This program shall incorporate a maintenance concept intended to minimize the mean time to restore (MTTR). System MTTR shall be sufficient to meet the availability requirements of Section 4.6.

4.6 AVAILABILITY

System availability shall be defined as follows:

System Intrinsic Availability = MTBF / (MTBF + MTTR)

where MTBF is defined as the system mean time between failures (i.e., the MTBF resulting from combining the MTBFs of all the individual equipment items), and MTTR is defined as the mean time to restore the system after a failure to any equipment in the system.

The System Intrinsic Availability for the low-cost CAI/CMI system shall be at least 0.98.

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